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ABSTRACT

This document covers approximately 500 publications developed by the University of Pittsburgh's Learning Research and Development Center (LRDC) from 1985 through 1991 and constitutes a record of LRDC's commitment to research that can strengthen educational practice. An abstract is provided for most entries. Each publication summarized addresses one or more of 19 research topics: (1) learning and instruction; (2) structures of knowledge, including concept development and the role of prior knowledge in learning; (3) assessment; (4) education reform; (5) school subjects, including mathematics, science, literacy-related subjects, such as reading, and social sciences; (6) reasoning; (7) technology; (8) group processes; (9) memory; (10) concept acquisition; (11) developmental psychology; (12) language and communications processes; (13) the nature of skill and expertise; (14) social and cultural influences on learning; (15) texts; (16) classroom teaching; (17) learning disabilities and special education; (18) technical training and work skills; and (19) skill acquisition. (BC)

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Learning Research and Development Center

Publications List
1985-1991

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Learning Research and Development Center

Publications List
1985-1991

Mission of the Learning Research and Development Center

The Learning Research and Development Center (LRDC) investigates processes of learning and instruction and works with teachers and school administrators to incorporate research findings into educational practice. During nearly three decades of research, LRDC scholars from several disciplines have contributed substantially to knowledge about human cognition, learning, and effective schooling. Projects today continue to study learning and teaching in school subject matters and technical fields, to examine the structure and components of effective learning environments, and to explore the nature and acquisition of high-level reasoning and problem-solving skills. Investigations also probe aspects of instructional design, assessment of learning outcomes, social processes of learning, and evaluation of classroom practices. Research findings are applied, in collaboration and communication with education practitioners, to the development of instructional materials and programs and to a variety of efforts to improve instruction and training in schools and workplaces. The publications listed in this volume reflect the breadth of this mission and constitute a record of LRDC's long-term commitment to research that can strengthen educational practice.

LRDC Research Scientists (1985-1991)

Kevin D. Ashley
Isabel L. Beck
William E. Bickel
Audrey B. Champagne*
Michelene T.H. Chi
William W. Cooley
Robert Glaser
Leopold E. Klopfer
Gaea Leinhardt
Alan Lesgold
John M. Levine
Margaret G. McKeown
Johanna D. Moore
Sharon A. Nelson-Le Gall
Stellan Ohlsson
Charles A. Perfetti
Lauren B. Resnick
Leslie Salmon-Cox
Leona Schauble
Walter Schneider
Janet W. Schofield
Jonathan W. Schooler
Edward A. Silver
Kurt VanLehn
James F. Voss
William D. Wattenmaker
Naomi Zigmond

* No longer at the Learning Research and Development Center

How to Use This Publications List

Entries in this list are organized alphabetically by author and chronologically within each author's entries. Single-author publications appear before those with multiple authors. Most references include a short abstract. The bracketed number(s) near the end of each abstract correspond(s) to the numbers on the Research Topic List below. The final number after each reference is the publication's serial number, which must appear on all orders for copies of the work.

To obtain copies of publications or publication lists, please use one of the two forms in the back of this list. Please refer to these forms for prices of documents, and enclose a check or money order made payable to **The University of Pittsburgh**. You should receive your order within two weeks of receipt of payment.

Research Topics

1. Learning and Instruction
2. Knowledge Structures for Learning (includes conceptual change, role of prior knowledge in learning, knowledge analysis, explanation, etc.)
3. Assessment and Evaluation
4. Education Reform (includes curriculum revision & development, staff development, classroom redesign, school restructuring, etc.)
5. Learning in School Subject Matters:
   a. Math
   b. Science
   c. Literacy (includes reading, writing, English, etc.)
   d. Social Science (includes history, geography, political science, and social studies)
6. Reasoning and Thinking
7. Learning and Technology
8. Group and Intergroup Processes
9. Memory and Learning
10. Concept Acquisition
11. Developmental Psychology
12. Language and Communication Processes
13. The Nature of Skill and Expertise
14. Social and Cultural Influences on Learning
15. Texts (includes text comprehension, learning from written material, and text processing)
16. Learning and Teaching in the Classroom
17. Learning Disabilities and Special Education
18. Technical Training and Work Skills
19. Skill Acquisition

LRDC Publications 1985-1991

Ackerman, P. L., & Schneider, W. (1985). Individual differences in automatic and controlled information processing. In R. F. Dillon (Ed.), *Individual differences in cognition* (Vol. 2, pp. 35-66). New York: Academic Press.

One major use of psychometric assessment procedures is to predict the performance of individuals after they experience a long training program. In order to improve predictions of training-program success, a better understanding of the relations between individual differences in abilities, underlying task characteristic, task performance, and practice effects are needed. In this chapter, the authors review how performance and information processing change with practice. [Topic: 19] 1985-001

Ackerman, P. L., Sternberg, R. J., & Glaser, R. (Eds.). (1989). *Learning and individual differences*. San Francisco, CA: Freeman.

This collection of articles treats major themes in the description of individual differences in learning from the point of view of theories of intelligence and implications for instruction. Interdisciplinary research in this area was first launched twenty years ago, and this volume represents the effort to assemble reports of major recent advances. [Topics: 1, 6, 9] 1989-001*

Ashley, K. D. (1991). Reasoning with cases and hypotheticals in Hypo. *International Journal Man-Machine Studies, 34*, 753-796.

HYPO is a case-based reasoning system that evaluates problems by comparing and contrasting them with cases from its Case Knowledge Base. It generates legal arguments citing the past cases as justification for legal conclusions about who should win in problem disputes involving trade secret law. HYPO's reasoning process and various computational definitions are described and illustrated, including its definitions for computing relevant similarities and differences, most on point and best cases to cite, four kinds of counterexamples, targets for hypotheticals and the aspects of a case that are salient in various argument roles. [Topics: 6, 9] 1991-001

Ashley, K. D. (Ed.). (1990). *Modeling legal argument: Reasoning with cases and hypotheticals*. Cambridge, MA: The MIT Press/Bradford Books.

HYPO is a case-based reasoning system that evaluates problems by comparing and contrasting them with cases from its Case Knowledge Base. It generates legal arguments citing the past cases as justifications for legal conclusions about who should win in problem disputes involving trade secret law. HYPO's reasoning process and various computational definitions are described and illustrated, including its definitions for computing relevant similarities and differences, most on point and best cases to cite, four kinds of counterexamples, targets for hypotheticals and the aspects of a case that are salient in various argument roles. [Topics: 6, 9] 1990-001*

Ashley, K. D., & Aleven, V. (1991). A computational approach to explaining case-based concepts of relevance in a tutorial context. In R. Bareiss (Ed.), *Proceedings of the Defense Advanced Research Projects Agency (DARPA) Case-Based Reasoning Workshop* (pp. 257-268). San Mateo, CA: Morgan Kaufmann.

This article describes a research project to devise and test an intelligent, case-based tutorial program for teaching law students to argue with cases. Using logical expressions in the knowledge representation language Loom, the authors explicitly represent case-based argument concepts such as a case's being on point to a problem, more on point than another case, most on point of all the cases, a best case to cite, and a counterexample to another case. [Topics: 2, 7, 10] 1991-002

Ashley, K. D., & Aleven, V. (1991). Toward an intelligent tutoring system for teaching law students to argue with cases. *Proceedings of the Third International Conference on AI and Law* (pp. 42-52). New York: The Association for Computer Machinery.

This article describes a research project to devise and test an intelligent, case-based tutorial program for teaching new law students to argue with cases. The program will be able to reason with the explicit concepts of relevance in selecting cases from a Case Library, assembling lessons and examples, analyzing student inputs, and in generating explanations and feedback. [Topics: 2, 7, 10] 1991-003

Baker, J., & Zigmond, N. (1990). Snapshots of an elementary school: Are regular education classes equipped to accommodate students with learning disabilities. *Exceptional Children, 56*(6), 515-526.

The study reported in this article examined educational practices in regular education classes in grades K-5 to determine changes required to facilitate a full-time mainstreaming program for students with learning disabilities. Data collected during the planning year of a mainstreaming project permitted a detailed analysis of the elementary school and the extent to which it accommodated individual differences. Data from informal structured observations, interviews, and surveys of students, parents, and teachers suggested that fundamental changes in instruction are necessary for the regular education initiative to work in this school. [Topic: 17] 1990-002

Beck, I. L. (1985). Digesting the mammoth [Review of *Handbook of Reading Research*]. *Journal of Reading Behavior, 17*(1), 55-65.
Review of P. D. Pearson (Ed.), *Handbook of Reading Research*. (1984). New York: Longman, Inc. [Topics: 12, 16] 1985-002

Beck, I. L. (1985). Five problems with children's comprehension in the primary grades. In J. Osborn, P. T. Wilson, & R. C. Anderson (Eds.), *Reading education: Foundations for a literate America* (pp. 239-253). Lexington, MA: Heath & Co.
This chapter examines reader and text characteristics that may cause a young reader's processing system to become overloaded. Recommendations are made for a two strand approach to reading instructions that integrates practice of lower-order skills on fairly easy text with opportunities to interact with more sophisticated textual material. [Topics: 12, 16] 1985-003

Beck, I. L. (1986). Using research on reading. *Educational Leadership, 43*(7), 13-15.
This article describes how becoming sensitive to the sometimes subtle relationship between background knowledge and text information can add to a teacher's repertoire of ways to promote students' understanding of what they read. [Topics: 12, 16] 1986-001

Beck, I. L. (1989). Improving practice through understanding reading. In L. B. Resnick and L. E. Klopfer (Eds.), *Toward the thinking curriculum: Current cognitive research. Yearbook of the Association for Supervision and Curriculum Development* (pp. 40-58). Alexandria, VA/Hillsdale, NJ: ASCD/Erlbaum.
This chapter describes how an understanding of the reading process can be a tool for helping to improve instructional practice. Highlighted in this discussion are the roles of word recognition efficiency, text structure, and background knowledge. [Topics: 6, 12, 16] 1989-002

Beck, I. L. (1989). Reading and reasoning: Reading programs are effective vehicles for enhancing reasoning skills. *The Reading Teacher, 42*(9), 676-682.
This article discusses how to take advantage of reading interactions to promote students' reasoning. The emphasis is on moving activities that are useful for developing higher-order thinking into the core of reading instruction. [Topics: 6, 12, 16] 1989-003

Beck, I. L., & Carpenter, P. A. (1986). Cognitive approaches to understanding reading: Implications for instructional practice. *American Psychologist, 41*(10), 1098-1105.
This article discusses three topics to convey some of the substantive progress made in research on the reading process: 1) elucidation of a general model of reading; 2) issues related to developing word recognition accuracy and efficiency; and 3) issues related to improving comprehension. [Topic: 12] 1986-002

Beck, I. L., & McKeown, M. G. (1985). Teaching vocabulary: Making the instruction fit the goal. *Educational Perspectives, 23*(1), 11-15.
This article addresses the issue of what makes for effective instruction in vocabulary. The emphasis is that different types of instruction are indicated depending on the goal of the instruction. [Topics: 10, 12, 16] 1985-004

Beck, I. L., & McKeown, M. G. (1987). Getting the most from basal reading selections. *The Elementary School Journal, 87*(3), 343-356.
This article examines instructional procedures for background knowledge and vocabulary development as presented in basal reading programs. Recommendations are made for tailoring instruction to individual needs and classroom goals. [Topics: 12, 15, 16] 1987-001

Beck, I. L., & McKeown, M. G. (1988). Toward meaningful accounts in history texts for young learners. *Educational Researcher, 17*(6), 31-39.
This article examines instructional sequences from four fifth-grade textbook series' treatments of the American Revolution. The work draws on cognitive research on comprehension and learning to bring into focus issues of learning that have direct bearing on textbook content and organization. [Topics: 5d, 15, 16] 1988-001

Beck, I. L., & McKeown, M. G. (1989). Expository text for young readers: The issue of coherence. In L. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 47-66). Hillsdale, NJ: Erlbaum.
This chapter focuses on coherence, the extent to which the sequence of ideas in a text makes sense and the presentation of information makes the nature of ideas and their relationships apparent. The construct of coherence is used for examining the comprehensibility of expository texts from basal reading textbooks. [Topics: 5c, 12, 15] 1989-004

Beck, I. L., & McKeown, M. G. (1991). Conditions of vocabulary acquisition. In P. D. Pearson (Ed.), *The handbook of reading research* (Vol. 2, pp. 789-814). New York: Longman.
This chapter examines current issues in vocabulary research. The first of two sections discusses what it means to know a word, issues in vocabulary size and growth, and how word knowledge is measured. The second section

considers sources for learning vocabulary, focusing on context and direct instruction. [Topics: 10, 12, 16] 1991-004

Beck, I. L., & McKeown, M. G. (1991). Social studies texts are hard to understand: Mediating some of the difficulties. *Language Arts, 68*, 482-490.
This article explores characteristics of expository texts that may make them difficult for young students and then describes research done with expository texts to address these problems. Suggestions for classroom instruction are also included. [Topics: 6, 15, 16] 1991-005

Beck, I. L., & McKeown, M. G. (1991). Substantive and methodological considerations for productive textbook analysis. In J. P. Shaver (Ed.), *Handbook of research on social studies teaching and learning* (pp. 496-512). New York: Macmillan.
This chapter considers how analyses of social studies textbooks can be made most productive toward addressing questions of the effectiveness of instruction and how students' learning might be improved. [Topics: 5d, 12, 15] 1991-006

Beck, I. L., McKeown, M. G., & Gromoll, E. W. (1989). Learning from social studies texts. *Cognition and Instruction*, 6(2), 99-158.
This article addresses issues in elementary social studies learning and makes suggestions for developing students' understanding by using resources such as tradebooks. [Topics: 5d, 15, 16] 1989-005

Beck, I. L., McKeown, M. G., & Omanson, R. C. (1987). The effects and uses of diverse vocabulary instructional techniques. In M. G. McKeown & M. E. Curtis (Eds.), *The nature of vocabulary acquisition* (pp. 147-163). Hillsdale, NJ: Erlbaum.
This chapter synthesizes a program of research to improve reading comprehension through vocabulary development. Discussion is then devoted to using the ideas from the research in setting up a classroom vocabulary program. [Topics: 10, 12, 16] 1987-002

Beck, I. L., McKeown, M. G., Sinatra, G. M., & Loxterman, J. A. (1991). Revising social studies text from a text-processing perspective: Evidence of improved comprehensibility. *Reading Research Quarterly, 26*, 251-276.
This article presents a study aimed at making revisions to fifth grade social studies texts based on a cognitive perspective, describing the revisions, and demonstrating their effects empirically. Recall and question data from fifth graders who read either original textbook versions or the revised versions showed that the revised versions were more effective. [Topics: 5d, 12, 15] 1991-007

Becker, J. P., Silver, E. A., Kantowski, M. G., Travers, K. J., & Wilson, J. W. (1990). Some observations of mathematics teaching in Japanese elementary and junior high schools. *Arithmetic Teacher, 38*, 12-21.
This article summarizes the classroom observations of the authors who, in the Fall of 1988, were in Japan to meet with Japanese counterparts to plan cross-cultural research in mathematics education. Findings on school and class atmosphere, organization of instruction, and open-ended problem solving and technology in the classroom are described and discussed. [Topics: 5c, 14, 16] 1990-003

Bickel, W. E. (1989). Essay review of *The client perspective on evaluation* by J. Nowakowski (Ed.). *Contemporary Psychology*, 34(9), 803.
This article is a review and critique of a recent book on the value of taking a client perspective for the organization of evaluation research. [Topic: 3] 1989-006

Bickel, W. E. (1990). The effective schools literature: Implications for research and practice. In T. B. Gutkin & C. R. Reynolds (Eds.), *The Handbook of School Psychology* (2nd ed., pp. 847-867). New York: Wiley & Sons.
This chapter summarizes recent research on effective schools for low achieving students and indicates new directions for research and practice based upon this work. [Topic: 4] 1990-004

Bickel, W. E. (1991). Essay review of: *Keeping students in school* by M. T. Orr. *Contemporary Psychology, 36*(1), 73.
This article is a review and critique of a recent book on effective programs for addressing the early school exit issue. [Topics: 4] 1991-008

Bickel, W. E., & Bickel, D. D. (1986). Effective schools, classrooms, and instruction: Implications for special education. *Exceptional Children*, 52(6), 489-500.
This article reviews the literatures on the characteristics of effective schools, classrooms, and instructional processes. Central findings from these literatures are summarized, as are important cautions in interpreting this knowledge base. The implications for special education of the effectiveness literatures are discussed. It is the position of the authors that both special and regular educators can learn much from recent research in order to design more powerful and integrated instructional programs for students with special needs. [Topics: 4, 17] 1986-050

Bickel, W. E., & Cooley, W. W. (1985). Decision-oriented educational research in school districts: The role of dissemination processes. *Studies in Educational Evaluation, 11*, 183-203.

Using case material from evaluations conducted in the Pittsburgh Public Schools, the authors discuss the role of the evaluator in the dissemination process to enhance the utilization of research-based information. [Topic: 3] 1985-005

Bickel, W. E., & Eichelberger, A. (1988). A conversation with Ed Meade. *Evaluation Practice*, 9(1), 39-49.

This article summarizes a lengthy interview with Ed Meade on the role of evaluation research in educational reform. The interview draws upon Mr. Meade's experiences in this area as a program officer for over a quarter of a century at the Ford Foundation. [Topic: 3] 1988-002

Bickel, W. E., Denton, S. E., Johnston, J. A., LeMahieu, P. G., Saltrick, D., & Young, J. R. (1987). Clinical teachers at the Schenley Teacher Center: Teacher professionalism and educational reform. *Journal of Staff Development*, *8*(2), 9-14.

The implications of teacher professionalism in setting and communicating standards for teaching are illuminated in a description of the role of the clinical resident teacher in the Schenley High School Teacher Center. [Topic: 4] 1987-003

Brown, C. A., & Silver, E. A. (1989). Data organization and interpretation. In M. M. Lindquist (Ed.), *Results of the fourth mathematics assessment of the National Assessment of Educational Progress* (pp. 28-34). Reston, VA: National Council of Teachers of Mathematics.

This chapter reports on student performance on data organization, data interpretation and statistical items on the fourth mathematics assessment conducted by the NAEP. The findings indicate that students at all three (3rd, 7th and 11th) grade levels have difficulty interpreting data presented in table or graph form in a problem-solving setting or when the presentation of the data or the task differed from standard textbook exercises. Students in the 7th and 11th grades appear to have little familiarity with technical statistical terms such as mean and mode, but can, generally, compute the mean when asked for the average. [Topics: 3, 5a] 1989-007

Brown, C. A., & Silver, E. A. (1989). Discrete mathematics. In M. M. Lindquist (Ed.), *Results of the fourth mathematics assessment of the National Assessment of Educational Progress* (pp. 19-27). Reston, VA: National Council of Teachers of Mathematics.

This chapter reports on student performance on probability, permutation and combination items on the fourth mathematics assessment conducted by the NAEP. The findings indicate that students at the 3rd grade level have difficulty with simple probability items. Students in the 7th and 11th grade are successful on items related to simple events but appear to have difficulty with probability items which deal with compound or independent events. Most 7th- and 11th-grade students are unable to solve problems involving permutations and combinations. [Topics: 3, 5a] 1989-008

Brown, C. A., Carpenter, T. P., Kouba, V. L., Lindquist, M. M., Silver, E. A., & Swafford, J. O. (1988). Secondary school results for the fourth NAEP Mathematics Assessment: Algebra, geometry, mathematical methods, and attitudes. *Mathematics Teacher*, *81*, 337-347,397.

This article is the second of three articles to appear in the Mathematics Teacher reporting the seventh-grade and eleventh-grade results of the fourth mathematics assessment of the National Assessment of Educational Progress (NAEP). This article reports students' performance on variables and relations, geometry, fundamental methods of mathematics, and attitudes. The findings for the eleventh-grade students were also analyzed by mathematics course background. The results indicate that, although performance is adequate on items requiring factual recall or simple procedural execution, secondary-school students are often unable to apply basic algebraic and geometric skills and concepts in problem-solving situations. [Topics: 3, 5a] 1988-003

Brown, C. A., Carpenter, T. P., Kouba, V. L., Lindquist, M. M., Silver, E. A., & Swafford, J. O. (1988). Secondary school results for the fourth NAEP Mathematics Assessment: Discrete mathematics, data organization and interpretation, measurement, number and operations. *Mathematics Teacher*, *81*, 241-248.

This article is the first of two articles in the Mathematics Teacher reporting on the seventh-grade and eleventh-grade results of the fourth mathematics assessment of the National Assessment of Educational Progress (NAEP) administered in 1986. This article reports on student performance in the areas of discrete mathematics, data organization and interpretation, measurement, numbers and operations. The results indicate that while secondary school students generally seem to have reasonably good procedural knowledge in such areas of mathematics as rational numbers, probability, measurement, and data organization and interpretation, they are lacking the conceptual knowledge that would enable them successfully to do the application, problem solving, and reasoning items on the assessment. [Topics: 3, 5a] 1988-004

Bundy, A., & Ohlsson, S. (1990). The nature of AI principles: A debate in the AISB Quarterly. In D. Partridge & Y. Wilks (Eds.), *The foundations of artificial intelligence: A sourcebook* (135-154). Cambridge, MA: Cambridge University Press.
In the AISB Quarterly no. 46, Stellan Ohlsson wrote an article attacking the prevailing methodology of AI as revealed by the papers at a major AI conference. Proposed was an alternative methodology. In the next issue, A. Bundy attacked Ohlsson's proposal. This sparked a debate between the two which lasted for seven AISBQ articles, and which constituted a lively investigation into the principles and methodology of AI. This article is a collection of seven articles. [Topics: 1, 7] 1990-005

Carlson, R. A., & Schneider, W. (1989). Acquisition context and the use of causal rules. *Memory & Cognition, 17*(3), 240-248.
Judgmental asymmetries in using causal knowledge (e.g., for prediction or diagnosis) have been attributed to the inherent directionality of causal knowledge. The present study examines the effect of acquisition context--representations used for initial instruction, and the type of judgment required for acquisition--on judgments using causal rules. This paradigm examined the development of procedures for using rules, rather than rule induction. After 200 trials of practice with each rule, subjects were transferred to the untrained judgment task. Transfer was strongly asymmetrical. Contrary to prediction, verification judgments always required more time. Results demonstrate that acquisition context may be partly responsible for judgmental symmetries, and imply that examining conditions of acquisition is important for understanding how causal knowledge is used. [Topic: 19] 1989-039

Carlson, R. A., & Schneider, W. (1989). Practice effects and composition: A reply to Anderson. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*(3), 531-533.
Anderson (1989) argues that the results of Carlson, Sullivan, & Schneider, 1989, confirm several predictions of the ACT* account of skill acquisition, including the occurrence of composition. The ACT* theory does include mechanisms that can account for the major ordinal results of these researchers' experiment. However, the quantitative implications of the mechanisms that Anderson invokes to support the occurrence of composition result in unreasonable or inconsistent predictions for the data set. These mechanisms do not account for the observed effects in their control experiment, make the composition hypothesis difficult to falsify, and involve assumptions that negate the processing speed advantage that composition would provide. The authors also discuss several other points made by Anderson. The results do provide weak support for some aspects of ACT*, while emphasizing the importance of quantitatively examining interrelations among mechanisms in complex models of skill acquisition. [Topic: 19] 1989-010

Carlson, R. A., Khoo, B. H., Yaure, R. G., & Schneider, W. (1990). Acquisition of a problem-solving skill: Levels of organization and use of working memory. *Journal of Experimental Psychology: General, 119*(2), 193-214.
The authors examined the acquisition of a problem-solving skill at three levels of organization--strategy, subgoal, and operator--and investigated changes in temporary storage, manipulation of information, and coordination of multiple representations. Six college students practiced minimizing the simulated cost of solving diagnostic problems with digital electronic circuits for approximately 50 hr. Subjects were tested on declarative knowledge, inferential skills at the subgoal level, and ability to solve problems during working memory tasks. The working memory tasks required retention of a preload, concurrent processing, or integration of displayed information with the contents of working memory. The data support the view that restructuring is goal sensitive and strategic. The results suggest a multiple-level analysis of skill acquisition in which practice allows strategic restructuring of cognitive processes at 3 levels of organization. [Topic: 19] 1990-006

Carlson, R. A., Khoo, B. H., Yaure, R. G., & Schneider, W. (1990). Working memory and skill acquisition: Reply to Halpern. *Journal of Experimental Psychology: General, 119*(3), 333-334.
Halpern (1990) argues that the authors' observations of subjects acquiring a complex problem-solving skill cannot be used to differentiate between single-workspace and distributed processing models of working memory. In this reply, the authors attempt to clarify the implications of their results for working memory models, and they discuss the nature of distributed-capacity models of working memory. It is difficult to discriminate the set of possible flexible single-workspace models from distributed models. The results do disconfirm major assumptions typical of single-workspace models and illustrate the kind of flexibility needed in a model of working memory. [Topics: 9, 19] 1990-007

Carlson, R. A., Sullivan, M. A., & Schneider, W. (1989). Component fluency in a problem-solving context. *Human Factors, 31*(5), 489-502.

Theories of cognitive skill suggest two hypotheses about component task practice. First, component task practice increases the speed of executing component skills during problem solving. Second, component practice produces component skills that behave as encapsulated subroutines. Eight college students practiced making judgments about digital logic gates for 1360 trials. At 2 points they solved circuit problems that did or did not require logic gate knowledge. Time per move declined with problem-solving practice but effects of component training were ambiguous. Teaching circuit functions did increase problem-solving speed. Component judgments were slower in the problem-solving context than in isolation, disconfirming this hypothesis. [Topic: 1f] 1989-011

Carlson, R. A., Sullivan, M. A., & Schneider, W. (1989). Practice and working memory effects in building procedural skill. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*(3), 517-526.

Several theories assume that practice (a) results in restructuring of component processes and (b) reduces demand on working memory. Eight subjects practiced judgments about digital logic gates for over 8,000 trials. At two practice levels, subjects made judgments while retaining short-term memory loads irrelevant to the judgments, relevant but not accessed, or accessed to make the judgments. Four phenomena together provide constraints for theory: performance declined in moving from blocked practice to randomized practice; gate and judgment type strongly affected latency; these effects declined but did not disappear with practice; and the cost of accessing information in working memory remained substantial. The results reflect a serial process with constant structure, while component processes become faster. The results challenge theories that all learning results from restructuring or that restructuring is an automatic consequence of practice, and support a distributed view of working memory. [Topic: 9] 1989-012

Carpenter, T. P., Lindquist, M. M., Brown, C. A., Kouba, V. L., Silver, E. A., & Swafford, J. O. (1988). Results of the fourth NAEP Assessment of Mathematics: Trends and conclusions. *Arithmetic Teacher, 36*, 38-41.

This article is the third of three articles to appear in the Arithmetic Teacher reporting the third-grade and seventh-grade results of the fourth mathematics assessment of the National Assessment of Educational Progress (NAEP). This article discusses general achievement trends and changes in performance over time across the national population, among minorities, and by gender. Specific attention is given to trends in the learning of concepts and skills and students' performance on items assessing problem-solving and mathematical reasoning abilities. [Topics: 3, 5a] 1988-005

Champagne, A. B., & Klopfer, L. E. (1991). Understanding science text and the physical world. In C. M. Santa & D. E. Alvermann (Eds.), *Science learning: Processes and applications* (pp. 64-73). Newark, DE: International Reading Association.

Observant science teachers have learned how misconceptions can interfere with students' understanding of force and motion. Because misconceptions are difficult to change with traditional science learning activities, the authors recommend alternative approaches that engage students in social interactions with their peers and their teachers. Students need to interact to clarify and elaborate on their views before, during, and after reading science text. In this chapter, the authors describe an interactive mapping strategy, called ConSAT, and show how the strategy works to induce conceptual change. [Topic: 5b] 1991-009

Champagne, A. B., Gunstone, R. F., & Klopfer, L. E. (1985). Effecting changes in cognitive structure among physics students. In L. H. T. West & A. L. Pines (Eds.), *Cognitive structure and conceptual change* (pp. 163-187). New York: Academic Press.

Recognizing the crucial need for effective instructional approaches that can help science students alter their declarative knowledge about the motion of objects, the authors designed a basic dialogue-based strategy: ideational confrontation. They investigated the extent to which this strategy facilitated conceptual change in two instructional groups--academically gifted middle-school students in Pittsburgh with demonstrated science interests, and university science graduates preparing to become high school science teachers in Victoria, Australia. The authors found that the ideational confrontation strategy was successful in producing changes in both groups' understanding of motion in the remarkably short time of 30 instructional hours. [Topic: 5b] 1985-006

Champagne, A. B., Gunstone, R. F., & Klopfer, L. E. (1985). Instructional consequences of students' knowledge about physical phenomena. In L. H. T. West & A. L. Pines (Eds.), *Cognitive structure and conceptual change* (pp. 61-90). New York: Academic Press.

Concerned about the often-documented difficulty that beginning physics students experience in learning classical mechanics, the authors identify and characterize the entering students' alternative conceptions of motion that contravene the physicists' declarative knowledge about motion. Taking the students' alternative conceptions seriously, the authors argue the necessity of deliberately altering the students' declarative knowledge to align it with that of the physicists, and they suggest several dialogue-based instructional strategies for effecting these changes. [Topic: 2] 1985-007

Champagne, A. B., Hoz, R., & Klopfer, L. E. (1987). *Construct validation of the cognitive structure of physics concepts*. Pittsburgh, PA: University of Pittsburgh, LRDC.

Utilizing a sample of 23 middle-school students, the authors investigated various theoretical and technical issues related to the construct validation of cognitive structure. They primarily wanted to determine the extent to which the representations of cognitive structure obtained via several data-gathering techniques and scaling methods can be relied upon as sources of meaningful and valid information about students' knowledge of physics concepts. The results allow the authors to address the practical questions of how cognitive structure probes can best be employed to inform instructional design and teaching practice. [Topic: 2] 1987-004

Chi, M. T. H. (1985). Changing conception of sources of memory development. *Human Development, 28*, 50-56.

Previously, explanations for memory development focused on acquisition of general strategies and metaknowledge. Recently, emphasis has shifted to the knowledge base as a whole, including general world-knowledge and domain-specific knowledge and procedures. Evidence is presented from the memory development literature showing why strategies and metaknowledge, although undoubtedly important in development, are not sufficient factors to account for memory development, especially if considered in isolation. Current research on the influence of the general knowledge base and the kinds of questions that must be considered by future research are summarized. [Topics: 2, 9, 11] 1985-008

Chi, M. T. H. (1985). Interactive roles of knowledge and strategies in the development of organized sorting and recall. In S. Chipman, J. Segal, & R. Glaser (Eds.), *Thinking and learning skills: Current research and open questions* (Vol. 2, pp. 457-483). Hillsdale, NJ: Erlbaum.

This chapter addresses the issue of how existing knowledge in semantic memory affects children's use of cognitive strategies. The author proposes that strategy use is not a simple matter of whether a given cognitive strategy is or is not available to and usable by the child depending on his stage of maturation. Instead, it appears that the use of a given cognitive strategy has a complex interaction with the amount and structure of the content knowledge to which the strategy is to be applied. Such a view suggests the possibility that maturation is correlated, but not causally related to the rate at which more knowledge is acquired, and also implies that the acquisition of this knowledge facilitates the acquisition and use of strategies. [Topics: 2, 6, 11] 1985-009

Chi, M. T. H. (1987). Representing knowledge and metaknowledge: Implications for interpreting metamemory research. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 211-232). Hillsdale, NJ: Erlbaum.

Children's memory development has traditionally been interpreted in terms of the development of control processes or strategies. However, careful consideration of the child's knowledge base reveals that so-called strategic deficiencies in young children may derive from an inadequate knowledge representation rather than the absence of mature strategies. This chapter is divided into four sections. The first section briefly describes why a knowledge emphasis is important in cognitive developmental psychology. The second section postulates a representational framework for the discussion of various forms of knowledge. Within the framework proposed, the third section evaluates the term metamemory and related research. The concluding section provides a general discussion. [Topics: 2, 9, 11] 1987-005

Chi, M. T. H. (1988). Children's lack of access and knowledge reorganization: An example from the concept of animism. In F. Weinert & M. Perlmutter (Eds.), *Memory development: Universal changes and individual differences* (pp. 169-194). Hillsdale, NJ: Erlbaum.

A popular interpretation for young children's limited performance is the concept of lack of access. This concept assumes that the knowledge that is needed to perform a task is available to the child, except that the child cannot access this knowledge or use it. This chapter attempts to understand this idea in terms of knowledge organization and how knowledge might be reorganized to facilitate access. The exact nature and definition of lack of access are postulated and preliminary exploratory data to demonstrate what

lack of access could mean for young children is presented in the domain of animism. [Topics: 2, 9] 1988-006

Chi, M. T. H. (1989). Assimilating evidence: The key to revision? [Commentary on P. Thagard's Explanatory Coherence]. *Behavioral and Brain Sciences*, 12(3), 470-471.

This commentary explores the application of Paul Thagard's theory of explanatory coherence within the field of psychology, with particular attention given to two crucial but unresolved issues: 1) How does conceptual change occur? and 2) What kinds of transition mechanisms are responsible for these changes? The most promising aspect of Thagard's theory is that it could potentially uncover precisely what factors contribute to restructuring (or to conceptual change) without postulating an explicit transition mechanism. Thagard's model, ECHO, is critiqued, both in terms of its potential to serve this purpose, as well as in terms of its actual accomplishments to date. [Topics: 2, 6, 9] 1989-013

Chi, M. T. H. (1990). Memory development. In M. W. Eysenck, A. Ellis, E. Hunt, & P. Johnson-Laird (Eds.), *The Blackwell dictionary of cognitive psychology* (pp. 218-222). Oxford, England: Basil Blackwell.

Memory development refers to the change in performance with age, in all kinds of memory tasks, such as recalling a sequence of digits, reconstructing experienced events, or remembering to carry out a chore. For all these types of tasks, performance improves with age, in terms of both quantitative measures (the amount of recall) as well as qualitative measures (the way it is recalled). Different memory tasks use different quantitative and qualitative measures. There are four possible explanations for such improvements with age. The two traditional explanations center on the capacity of short term memory, and on the strategies that adults and children use to carry out such tasks. The contemporary explanations center on either the domain specific or word knowledge that the child has gained with maturation. Each of these four explanations is presented, along with challenges to some of them. [Topics: 2, 9, 11] 1990-0[illegible]

Chi, M. T. H., & Bassok, M. (1989). Learning from examples via self-explanations. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 251-282). Hillsdale, NJ: Erlbaum.

To study how one learns to solve problems, the authors examined the ways students learn from worked-out examples in text in the domain of physics. "Good" students' learning from examples was characterized by self-explanations which displayed the addition of tacit knowledge about the actions of the example solutions as well as greater understanding of the principles introduced in the text. "Good" students' self-monitoring was also more accurate. Knowledge that they misunderstood elicited explanations and specific inquiries through which "good" students then search for an answer. Issues concerning learning with understanding, generalizing problem solving skills and instructional implications are discussed. [Topics: 2, 6] 1989-014

Chi, M. T. H., & Bjork, R. (1991). Modeling expertise. In D. Druckman & R. A. Bjork (Eds.), *In the mind's eye: Enhancing human performance*. Washington, DC: National Academy Press

This chapter has four main sections. In the first section, the authors note that complex cognitive skills may not be readily learned by modelling or imitating expert behavior. In the second section, they review ways in which experts excel, other than in the given skill itself, and the ways their abilities and other skills are not exceptional. Since their expertise is based on the knowledge that they possess, which in turn generates the actions they take, the authors focus in the third section on the difficult process of extracting an expert's knowledge. Several knowledge elicitation methods are reviewed. Finally, the last section focuses on how knowledge extracted from experts can be imparted to novices. [Topics: 2, 13, 19] 1991-010

Chi, M. T. H., & Ceci, S. J. (1987). Content knowledge: Its role, representation and restructuring in memory development. In H. W. Reese (Ed.), *Advances in child development and behavior* (Vol. 20, pp. 91-142). New York: Academic Press.

Only since the mid-1970s have researchers directly examined the role of knowledge in memory development. The authors begin this chapter with a discussion of the forces that are responsible for this shift in emphasis. Next, they selectively review specific studies that demonstrate the causative role of knowledge in producing age-related differences in memory. Finally, drawing upon empirical studies and theoretical analyses, they examine how the knowledge structure changes with development. In this discussion, the authors emphasize the role of one type of knowledge as it relates to memory, namely content knowledge. This near exclusive emphasis on content knowledge is a result of its demonstrable influence on children's memory performance. [Topics: 2, 6, 9] 1987-006

Chi, M. T. H., & Glaser, R. (1985). Problem solving ability. In R. J. Sternberg (Ed.), *Human abilities: An*

information-processing approach (pp. 227-250). New York: Freeman.
This chapter presents an overview of the general characteristics of human problem solving ability. Two important factors that influence problem solving are the nature of the task (the task environment) and the knowledge brought to the problem by the solver. The centrality of these two factors dictates the organization of this chapter. In the first main section, the authors consider puzzle problems and general processes of solution. In the second, they discuss the solving of problems that require domain knowledge. The authors also consider various task environments that involve insight, creativity, and ill-structured problems. [Topics: 2, 6, 13] 1985-010

Chi, M. T. H., & Greeno, J. G. (1987). Cognitive research relevant to education. *Psychology and Educational Policy, 517*, 39-57.
The authors consider cognitive research relevant to the teaching of higher-order skills in problem-solving and reasoning as well as to the understanding of general concepts. It is recognized that instruction in specific content knowledge and procedures for solving specific problems often fails to produce transfer. It would be desirable, therefore, to increase the generality of knowledge that students acquire. One approach is to focus on general methods and strategies of problem-solving--a necessary goal of education because we can predict neither what knowledge students will need nor what problems they will have to solve during life. [Topics: 2, 6, 9] 1987-007

Chi, M. T. H., & VanLehn, K. A. (1991). The content of physics self-explanations. *The journal of the Learning Sciences, 1*(1), 69-105.
Several earlier studies have found that the amount learned while studying worked-out examples is proportional to the number of self-explanations generated while studying examples. A self-explanation is a comment about an example statement that contains domain-relevant information over and above what was contained in the example line itself. This article analyzes the specific content of self-explanations generated by students while studying physics examples. Results suggest that in generating self-explanations, students both deduce from prior knowledge and generalize from example statements, yielding new general knowledge that helps complete an otherwise incomplete understanding of domain principles and concepts. The relevance of this research for instruction and models of explanation-based learning is also discussed. [Topics: 2, 5b, 10] 1991-011

Chi, M. T. H., Bassok, M., Lewis, M. W., Reimann, P., & Glaser, R. (1989). Self-explanations: How students study and use examples in learning to solve problems. *Cognitive Science, 13*, 145-182.
This article analyzes the self-generated explanations (from talk-aloud protocols) that "good" and "poor" students produce while studying worked-out examples of mechanics problems, as well as their subsequent reliance on examples during problem solving. The findings suggest that "good" students learn with understanding: they generate many explanations which refine and expand the conditions for the action parts of the example solutions and relate these actions to principles in the text. These self-explanations are guided by accurate monitoring of their own understanding. "Poor" students generate insufficient self-explanations, monitor their own learning inaccurately, and subsequently rely heavily on worked-out examples. The closing discussion is then devoted to the role of self-explanations in facilitating problem solving, as well as the adequacy of current AI models of explanation-based learning to account for these psychological findings. [Topics: 2, 5b, 13] 1989-015

Chi, M. T. H., Chiu, M. H., & de Leeuw, N. (1991). *Learning in a non-physical science domain: The human circulatory system.* Pittsburgh, PA: University of Pittsburgh, LRDC.
This report explores four dimensions of difference between physics topics and the biology topic of the human circulatory system. First, physics requires nomological deductions from principles, while the human circulatory system requires the understanding of component interactions. Second, difficulty in physics arises from the mismatch of sensory information and scientific conceptions. In biology, difficulties arise from the complexity or the difficulty of direct observation. Third, the pattern of misconceptions is more robust in physics. Finally, removing physics misconceptions requires radical change, but removing circulatory misconceptions does not. Analysis of talking out-loud protocols on the circulatory system demonstrated that misconceptions were generally removed when the text addressed them, and that the nature of change was incremental rather than radical. [Topics: 5b, 10, 15] 1991-012

Chi, M. T. H., Chiu, M. H., de Leeuw, N., & LaVancher, C. (1991). *The use of self-explanations as a learning tool.* Pittsburgh, PA: University of Pittsburgh, LRDC.
This report explores misconceptions and their removal, focusing on the human circulatory system. There is an ontological distinction

between this domain and physical science domains. While naive notions of certain physics concepts are incompatible with their scientific conceptions, naive understandings of the circulatory system are not. This distinction predicts that misconceptions about the circulatory system should be relatively easy to remove, and evidence is presented to that effect. One avenue for misconception removal is the use of self-explanations. Students prompted to self-explain each line of a text showed significant improvement from pre-test to post-test, while control group students who did not self-explain did not show this improvement. [Topics: 5b, 10, 15] 1991-013

Chi, M. T. H., Glaser, R., & Farr, M. J. (Eds.). (1988). *The nature of expertise*. Hillsdale, NJ: Erlbaum.
The majority of the chapters in this volume were presented at a conference held at the Learning Research and Development Center at the University of Pittsburgh, sponsored by the Personnel and Training Research Program, Office of Naval Research. The chapters focus on four areas: practical skills, programming skills, medical diagnosis, and ill-defined problems. For each domain, work that is representative and offers a diversity of approaches is assembled. The different approaches employed show the influence of methodologies from cognitive psychology, artificial intelligence, and cognitive science in general. The chapters also make a case for increased attention to learning--to how expertise is acquired and to the conditions that enhance and limit the development of high levels of cognitive skill. [Topics: 6, 13, 19] 1988-007*

Chi, M. T. H., Hutchinson, J. E., & Robin, A. F. (1989). How inferences about novel domain-related concepts can be constrained by structured knowledge. *Merrill-Palmer Quarterly, 35*(1), 27-62.
Three studies are focused on (a) the definition of structure in a specific domain of knowledge (in this case, dinosaurs), and (b) the relationship between how knowledge is structured and how it is used. The evidence suggests that the knowledge of children who are experts on dinosaurs is structured hierarchically into well-defined families and family groups. Furthermore, within each level of this hierarchy, the knowledge appears to be locally cohesive. Greater hierarchical structure allows expert children to use domain features to generate causal explanations, use categorical reasoning, induce attributes about novel dinosaurs, and sort dinosaurs into well-defined family types. The consequences of hierarchically structured knowledge is that expert children can use it to constrain their inferences, whereas novices must rely on their general world knowledge, thereby making less accurate and often inappropriate inferences. [Topics: 2, 11, 13] 1989-016

Chi, M. T. H., Robin, A. F., Strikey, J., & Fallshore, M. (1989). *Possible source of misunderstanding about the circulatory system*. Pittsburgh, PA: University of Pittsburgh, LRDC.
This report contrasts misconceptions in the physical and biological sciences. While understanding physics requires one to acquire and understand scientific laws, understanding the circulatory system requires one to understand the interactions among components. Misconceptions or misunderstandings of the circulatory system can derive from the omission in textbooks of causal relations among components. [Topics: 5b, 10, 15] 1989-017

Chipman, S. F., Segal, J. W., & Glaser, R. (Eds.). (1985). *Thinking and learning skills: Research and open questions* (Vol. 2). Hillsdale, NJ: Erlbaum.
This volume assembles leading researchers' analyses of findings from cognitive and instructional psychology that speak to the problem of fostering higher order thinking skills. Research on the influence of knowledge on problem solving suggests that instruction on these skills be carried out in the context of school subject matters. [Topics: 1, 6, 14] 1985-011*

Cohan, S., & Zigmond, N. (1986). The social integration of learning disabled students from self-contained to mainstream elementary school settings. *Journal of Learning Disabilities, 19*(10), 614-618.
The study reported in this article had two purposes: (1) to investigate the social status of learning disabled students and (2) to compare the outcome differences of a rating scale sociometric with those of a peer nomination measure. [Topics: 17] 1986-003

Cooley, W. (1989). *Inequalities and inequities in the Pennsylvania public schools*. Pittsburgh, PA: University of Pittsburgh, LRDC.
Pennsylvania's method of financing its public schools results in disparities between wealthy and poor districts that are similar to those that have been declared unconstitutional in other states. This report examines the nature of those school district differences, the reasons why those disparities exist, and why it is important for Pennsylvania's law makers and policy boards to reduce them. The author examines the various kinds of inequalities that exist in the Commonwealth: in financial inputs, in instructional resources, and in student outcomes. A serious problem is that districts that face the

most difficult educational task tend to have inadequate instructional resources for dealing with it. The primary purpose of the report is to contribute to a more informed debate about the need for greater equity in school finance. [Topics: 3, 4] 1989-018

Cooley, W. (1990). *Important variations among Pennsylvania school districts.* Pittsburgh, PA: University of Pittsburgh, LRDC.
This report, the fourth of a series of Pennsylvania Educational Policy Studies, describes how financial data, teacher data, and student achievement are interrelated. The 500 school districts in Pennsylvania exhibit very large and fascinating variations. Examples include the variation in student enrollment, in local revenues, in total expenditures per pupil, in average teacher salaries, in average number of students per teacher, in percent of students from welfare homes, and in percent of students with below standard achievement. The purpose of this report is to explore these variations and to examine the ways in which differences on one dimension may be affecting differences on other dimensions. [Topics: 3, 4] 1990-009

Cooley, W. (1990). *Student assessment in Pennsylvania.* Pittsburgh, PA: University of Pittsburgh, LRDC.
This report is the sixth of a series of Pennsylvania Educational Policy Studies. The author recommends a statewide student assessment system to replace the TELLS test. [Topics: 3, 4] 1990-010

Cooley, W. W. (1987). Developing an elementary school information system: Computer assisted professional. In A. Bank & R. C. Williams (Eds.), *Information systems and school improvement: Inventing the future* (pp. 86-96). New York: Teachers College Press.
During the school year 1984-85, staff members from the Learning Research and Development Center (LRDC) worked with the Pittsburgh Public Schools in the development of a prototype microcomputer system in an elementary school. The system was designed to help the principal become a more effective instructional leader; facilitate the implementation of two district innovations, Monitoring Achievement in Pittsburgh (MAP) and the School Improvement Program (SIP); encourage other professionals in the school to become more data-based in their planning and decision making; and make possible a more current and accurate district-wide data base. The intent was for the school-based microcomputer to complement the functions of the central computer system. This chapter describes the reasons for developing such a system, what it does, and how it is built. [Topics: 3, 4] 1987-008

Cooley, W. W. (1988). Ec[illegible]ation indicators within school districts. In R. Haskins (Ed.), *Policies for America's public schools: Teachers, equity, and indicators* (pp. 197-212). Norwood, NJ: Ablex.
This chapter argues that school district research offices should shift from an emphasis on summative evaluations of specific programs, to an emphasis upon developing and monitoring indicators of their educational system. The characteristics of an effective information system for school districts are described. [Topics: 3, 4] 1988-008

Cooley, W. W. (1989). Evaluating with theory. *Contemporary Psychology, 34*(2), 188-189.
This article is a review of Leonard Bickman's book, Using Program Theory in Evaluation. (1987). San Francisco: Jossey-Bass. [Topic: 3] 1989-019

Cooley, W. W. (1990). *Confidentiality of educational data and data access.* Pittsburgh, PA: University of Pittsburgh, LRDC.
This report is number seven in a series of Pennsylvania Educational Policy Studies. The author discusses the privacy issues involved in establishing research data bases. [Topics: 3, 4] 1990-011

Cooley, W. W. (1990). The complete educator. *Educational Researcher, 19*(9), pp. 29-30.
This article is a review of *Educational Evaluation: Classic Works of Ralph W. Tyler.* (1989). George F. Madaus and Daniel L. Stufflebeam (Eds.). Boston: Kluwer Academic Publishers. [Topic: 3] 1990-012

Cooley, W. W. (1991). *Fiscal strain in Pennsylvania's school districts.* Pittsburgh, PA: University of Pittsburgh, LRDC.
This report is number eight in a series of Pennsylvania Educational Policy Studies. It is easy to find extreme differences between the state's richest and poorest school districts in terms of expenditures per pupil, teacher salaries, and student-teacher ratio. But in addition to such inequalities in current status, there are differences in five year trends. The author compares the average percent change in the 100 richest and the 100 poorest districts between 1985 and 1989 in terms of increases in state funding, increases in local revenues, and local tax effort. These and other five year trends are explored in this report, together, with how those changes interact with changes in enrollment. [Topics: 3, 4] 1991-014

Cooley, W. W. (1991). *School choice or school reform.* Pittsburgh, PA: University of Pittsburgh, LRDC.
This report is number 12 in a series of Pennsylvania Educational Policy Studies. The author considers current legislation for school

vouchers and suggests an alternative reform strategy. [Topics: 3, 4] 1991-015

Cooley, W. W. (1991). *Testing and school improvement*. Pittsburgh, PA: University of Pittsburgh, LRDC.
This report is number nine in a series of Pennsylvania Educational Policy Studies. The author examines five years of state test results (TELLS), focusing upon differences among Pennsylvania's elementary schools, particularly those schools with a majority of their students not mastering essential learning skills. [Topics: 3, 4] 1991-016

Cooley, W. W., & Bernauer, J. A. (1990). *School comparisons in state wide testing programs*. Pittsburgh, PA: University of Pittsburgh, LRDC.
This report is the third of a series of Pennsylvania Educational Policy Studies. The authors explain why school comparisons of student achievement are usually misleading and describes how to make them more interpretable. [Topics: 3, 4] 1990-013

Cooley, W. W., & Bernauer, J. A. (1991). School comparisons in statewide testing programs. In R. Stake (Ed.), *Advances in program evaluation (Part A)* (pp. 159-170). Greenwich, CN: JAI Press.
Publishing lists of academically troubled schools has become a favorite form of accountability in many states. A recent New York Times editorial, titled Finger-Pointing Won't Help Schools (1989), pointed out that the official identification of failing schools only serves to demoralize them unless the state is prepared to offer substantive help. The chapter addresses some of the issues surrounding this very important controversy, focusing upon the state of Pennsylvania and using the Pennsylvania Educational Policy Studies (PEPS) database to illustrate the points being made. [Topics: 3, 4] 1991-017

Cooley, W. W., & Bickel, W. E. (1986). *Decision-oriented educational research*. Boston, MA: Kluwer-Nijhoff Publishing.
In this book, the authors describe a strategy for increasing the quality and use of evaluation research in educational systems. Decision-Oriented Educational Research (DOER) is based upon eleven actual cases of evaluation research conducted in the Pittsburgh Public Schools over the course of a five year period. [Topic: 3] 1986-004*

Cooley, W. W., & McClure, M. W. (1989). The public schools and regional economic change. In R. L. Bangs & V. P. Singh (Eds.), *The state of the region* (pp. 69-86). University Center for Social and Urban Research.
This report is the first of a series of Pennsylvania Educational Policy Studies. The purpose of the series is to contribute to a more informed debate about critical policy issues facing Pennsylvania's public schools. This first report focuses on southwestern Pennsylvania. [Topics: 3, 4] 1989-020

DeBettencourt, L. U., & Zigmond, N. (1990). The learning disabled secondary school dropout: What teachers should know, what teachers can do. *TESE, 13*(1), 17-20.
A disproportionately large number of learning disabled students are leaving high school before graduation. While the solutions are not simple, previous research and experience indicate that teachers can play a significant role in preventing dropout among learning disabled adolescents. Potential interventions are discussed. [Topic: 17] 1990-014

DeBettencourt, L. U., Zigmond, N., & Thornton, H. (1989). Follow-up of post-secondary age rural learning disabled graduates and dropouts. *Exceptional Children, 56*(1), 40-49.
This article reports the dropout rates, basic skill competency levels, and employment status of a group of semi-rural learning disabled post-secondary age youth and a control group of non-learning disabled same age peers. Findings indicate significantly higher dropout rates and significantly lower basic skills competency levels among LD youth. LD graduates and dropouts were not different in how they fared in the employment market for the group, nor were they different compared to peers. [Topic: 17] 1989-021

DeCooke, P., & Nelson-Le Gall, S. (1989). The effects of familiarity on the success of children's help seeking. *Journal of Applied Developmental Psychology, 10*, 195-208.
This study assessed the impact of familiarity on the success of children's help seeking from peers. The helping interactions of 40 children in the third through fifth grades were observed during their classroom activities. The amount of visual regard that children received from peers was included as a sociometric measure. Learning Disabled (LD) and Socially and Emotionally Disturbed (SED) students from self-contained classrooms, segregated to the greatest extent, had the least success of any group in their help seeking. LD and SED students from resource rooms, mainstreamed for most classes, were more similar to nonlabeled students in the pattern of their help seeking. Both groups of labeled children, but especially the self-contained classroom students, received less visual regard from nonlabeled students. The more familiar labeled students were to their classmates, the more accepted they were, and the more likely they were to have their

help-seeking requests accepted. [Topics: 14, 16] 1989-022

DeFigio, N., & Zigmond, N. (1990). Using a needs assessment instrument to evaluate the impact of a staff development program on the role and function of the principal. *IJE, 3*(1), 37-51.
The study reported in this article involved the use of an existing database to provide indirect evidence of the impact of a staff development program. Data from needs assessment surveys administered to building administrators, supervisors, and classroom teachers in a large urban school district before and after a major staff development initiative were analyzed to evaluate the impact of the training effort on participants' perceptions of district needs. The first administration of the needs assessment survey occurred in 1980; the second administration of a similar needs assessment survey occurred in 1986. Changes in those items on the survey that related to curriculum, testing, staff development, personnel evaluation, and personnel roles were used as indicators of the effects of the staff development effort. [Topic: 3] 1990-015

DeFigio, N., Zigmond, N., & LeMahieu, P. (1990). Educators' views of educational problems: Changes related to a staff development initiative, 1980-86. *ERS Spectrum, 8*(1), 39-47.
Increasingly, demands for more effective public schools are coming from public figures, the media, and the educational community itself. One of the ways that school districts respond to such demands is by trying to improve the performance of teachers and administrators through new staff development initiatives. The study described in this article involved the use of an existing database, initially compiled to provide information about needs and priorities in a large, urban school districts. Needs assessment surveys were administered to the district's building-level administrators, supervisors, and classroom teachers in 1980 and 1986, before and after a major staff development initiative. The study reported in this article analyzed data from these surveys to evaluate the impact of the staff development program on participants' perceptions of district needs. [Topic: 4] 1990-016

Desimone, R., Wessinger, M., Thomas, L., & Schneider, W. (1990). Attentional control of visual perception: Cortical and subcortical mechanisms. *Cold Spring Harbor Symposium on quantitative biology* (Vol. 55, pp. 963-997). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
The physiology of the attentional control is briefly reviewed, describing how receptive fields increase in size levels in visual processing in the monkey. Attention effectively increases the resolution of features in the receptive field of higher level visual areas. The role of the pulvinar in attention is reviewed. A deactivation study is described in which muscimole injections into laternal pulvinar produce no effect of processing single stimuli but substantially increase errors in the monkey when there is a distracting stimuli in the opposite hemifield. Similar results were found with superior colliculus deactivation. A qualitative model of attentional competition is described in which the relative activation of regions determine the likelihood that they are attended. [Topic: 9] 1990-017

Detweiler, M., & Schneider, W. (1987). A connectionist/control architecture for working memory and workload: Why working memory is not 7 +/- 2. *Proceedings of the Human Factors Society* (pp. 684-688). Santa Monica, CA: Human Factors Society.
A runnable simulation architecture for working memory is described that provides an alternative to existing models of working memory. It is used to interpret a variety of phenomena, including multiple resources, workload, chunking, sequential output, skilled and episodic memories, and stages of skill acquisition. The architecture is based on a set of modules organized into regions which communicate with each other on an innerloop of processing. A new feature of this architecture is a proposed context-storage module that temporarily stores context information in fast changing connection weights. This enables the system to expand working memory beyond the typical 7 +/- 2 items. The context storage system is able to reload modules after short-term information decays or is displaced; in addition, it provides a means of achieving stable, robust processing under conditions of high workload. [Topics: 9, 19] 1987-009

Detweiler, M., & Schneider, W. (1991). Modeling the acquisition of dual task skill in a connectionist/control architecture. In D. Damos (Ed.), *Multiple-task performance: Selected topics* (pp. 69-98). London: Taylor & Francis.
A hybrid connectionist/symbolic architecture for skill acquisition in dual task situations is described in this chapter. It is used to interpret a variety of skill acquisition phenomena, including multiple resources, workload, single/dual task transfer, and stages of skill acquisition. The architecture is based on a set of modules organized into regions which communicate with each other on an innerloop of processing. Five stages of skill acquisition are detailed as

performance becomes more automatic. Seven compensatory activities occur in the architecture during dual-task training that do not appear in single-task training, including (1) shedding and delaying tasks and preloading buffers, (2) letting go of high-workload strategies, (3) utilizing noncompeting resources, (4) multiplexing over time, (5) shortening transmissions, (6) converting interference from concurrent transmissions, and (7) chunking of transmissions. [Topic: 19] 1991-018

Donahoe, K., & Zigmond, N. (1990). Academic grades of ninth-grade urban Learning Disabled students and low-achieving peers. *Exceptionality, 1*, 17-27.
The first purpose of the study reported in this article was to describe and analyze the academic performance of secondary learning-disabled students in regular education classes. The authors accomplished this by collecting the grades these students earned in three academic mainstream classes. The grades of low-achieving students were also collected to provide a basis for comparison. The results indicated that there were significant differences in the distribution of grades earned by the two groups in social studies and health, but not significant differences between the grades earned in science. The second purpose of the study was to determine if selected variables (intelligence quotients, reading level, and absence rates) differentiated learning disabled students who passed ninth grade from those who did not. Of these variables, only absence rate discriminated between passers and failers. [Topic: 17] 1990-018

Eberts, R., & Schneider, W. (1986). Effects of perceptual training of sequenced line movements. *Perception and Psychophysics, 39*(4), 236-247.
The effects of consistent training on sequential stimuli were examined in a series of six experiments. A stimulus consisted of three line segments which occurred one after another such that each line segment's orientation and position on the visual channel could be different from the other lines of the stimulus. Subjects practiced these sequences in search and detection tasks for 17 h in both varied mapping (VM) and consistent mapping (CM) conditions. The results indicated that the CM stimuli required less attention then the VM stimuli. Large differences between the CM and VM groups were found when the individual line segments of the sequential stimuli were manipulated. Presenting rotated versions of the trained stimuli destroyed any performance advantages the CM stimuli had over the VM stimuli. [Topic: 19] 1986-005

Ernst, A. M., & Ohlsson, S. (1989). *The cognitive complexity of the regrouping and augmenting algorithms for subtraction: A theoretical analysis* (Tech. Rep. No. KUL-89-06). Pittsburgh, PA: University of Pittsburgh, LRDC.
This study shows that the pedagogical arguments about the difficulty of mathematical skills cannot be based on subject matter analysis alone, but must be grounded in psychological theory. Described are two psychological models, implemented as production systems, that simulate the cognitive processes involved in subtraction, including the perceptual-motor processes. The results of running the models favor augmenting over regrouping, consistent with the pattern of empirical results in the research literature, but contrary to the current instructional practice in American schools. [Topics: 2, 5a] 1989-023

Fincher-Kiefer, R. H., Post, T. A., Greene, T. R., & Voss, J. F. (1988). On the role of prior knowledge and task demands in the processing of text. *Journal of Memory and Language, 27*, 416-428.
Two experiments addressed the question of whether demands produced by the processing of domain-related information varied as a function of a person's domain knowledge. The results, taken with other findings, indicate that domain knowledge influences processing at a situational model or mental model level but not at a microlevel or propositional level. The results also suggest that a motivational component influences the processing of high knowledge individuals yielding greater concentration, and support the use of M. Daneman and P. A. Carpenter's (1980) reading span task as an index of processing efficiency. [Topic: 2] 1988-009

Fisk, A. D., Ackerman, P. L., & Schneider, W. (1987). Automatic and controlled processing theory and its application to human factors problems. In P. A. Hancock (Ed.), *Human factors in psychology* (pp. 159-197). New York: Elsevier Science Publishers.
This chapter reviews the applicability of automatic/controlled processing theory from a human factors perspective. The basic behavioral search tasks and results are described detailing qualitative differences in the two processing modes. The generalizability to complex tasks and the reliability of automatic processes under stress are reviewed. Automatic/controlled processing theory facilitates the interpretation of individual differences particularly the changing nature of task loadings in general intelligence and perceptual factors as practice develops. [Topic: 19] 1987-010

Fisk, A. D., Derrick, W. L., & Schneider, W. (1987). A methodological assessment and evaluation of

dual-task paradigms. *Current Psychological Research and Reviews*, 5(4), 315-327.
This article outlines three major assumptions often implicitly made in dual-task experiments conducted to assess attentional capacity requirements of memorial processes. These assumptions are shown to be incorrect. Three criteria which should be met in dual-task experiments that draw inferences from secondary task decrements are proposed: (1) there should be a resource trade-off with the secondary task sensitive to the resource demands of the primary task; (2) there should be an equivalence of single and dual primary task performance; and (3) the secondary task must remain resource sensitive throughout experiments. Results demonstrate that when criteria are met, secondary task performance can be predictive of primary task difficulty. [Topic: 19] 1987-011

Fox, D. L., & Schofield, J. W. (1989). Issue salience, perceived efficacy and perceived risk: A study of the origins of anti-nuclear war activity. *Journal of Applied Social Psychology*, 19(10), 805-827.
This article describes an experiment designed to explore the origins of anti-nuclear war activism. In Session 1, participants completed questionnaires assessing numerous attitudes including perceived political efficacy in the nuclear realm. One week later both the salience of the nuclear weapons issue and participants' sense of personalized risk were experimentally manipulated. Dependent measures were a behavioral intentions questionnaire and an actual opportunity to sign a petition. High salience significantly increased both anti-nuclear war behavioral intentions and actual behavior. Individuals who felt highly efficacious were also significantly more likely to take action than others. A similar relation between efficacy and behavioral intentions was not found, although a salience by efficacy interaction was. Personalized risk influenced only behavioral intentions. 1989-024

Frederiksen, N., Glaser, R., Lesgold, A. M., & Shafto, M. (Eds.). (1990). *Diagnostic monitoring of skill and knowledge acquisition*. Hillsdale, NJ: Erlbaum.
This book assembles reports of research on topics directly bearing on the assessment of real, valuable skill and thinking rather than simple recall. Throughout, the perspective on the research is informed by cognitive science. [Topics: 3, 18] 1990-019*

Gabrys, G., & Lesgold, A. (1989). Coherence: Beyond constraint satisfaction [Invited commentary on an article by Thagard]. *Behavioral and Brain Sciences*, 12, 475.
The authors discuss ECHO, a computer model of change in causal theories. Echo models explanatory coherence as a constraint satisfaction problem. Debate about the model might focus on certain choices of weights, linking mechanisms, and decay parameters. It might be possible to have a system that combines ECHO-like reasoning with dialectical reasoning. Dialectical reasoning could use different weighting schemes and analyze how they differ. [Topic: 6] 1989-025

Gagne, R., & Glaser, R. (1987). Foundations in learning research. In R. M. Gagne (Ed.), *Instructional technology: Foundations* (pp. 49-83). Hillsdale, NJ: Erlbaum.
The how-to-do-it knowledge that informs work in the design of instructional technologies is reviewed here. The range of research on fundamental aspects of cognition that is treated includes memory, knowledge structures, and self-regulation, each of which must be intensively considered where the aim is to support learning effectively. [Topics: 1, 2, 7] 1987-012

Gitomer, D. H., & Glaser, R. (1987). If you don't know it work on it: Knowledge, self-regulation and instruction. In R. E. Snow & M. Farr (Eds.), *Aptitude, learning and instruction: Cognitive and affective process analyses* (Vol. 3, pp. 301-325). Hillsdale, NJ: Erlbaum.
Two characteristics of performance that are acquired through learning and experience are examined: well-organized knowledge structures and self-regulatory skills. This discussion focuses on the role these characteristics play in the progress from novice to competent performance and addresses related developmental research to illustrate implications of new findings on cognitive skill acquisition for instructional theory. [Topics: 1, 6] 1987-013

Gitomer, D. H., Curtis, M. E., Glaser, R., & Lensky, D. B. (1987). Processing differences as a function of item difficulty in verbal analogy performance. *Journal of Educational Psychology*, 79(3), 212-219.
This article describes a study that evaluated processing of verbal analogies by recording eye fixation patterns during problem solution. On difficult problems, high-verbal individuals tended to adapt their processing strategies to a much greater extent than did low-verbal students. Current models cannot account for variation in performances when experimental items resemble aptitude test items. Instead, models that incorporate both individual differences and item characteristics are needed. [Topic: 12] 1987-014

Glaser, R. (1985). Cognition and adaptive education. In M. C. Wang & H. J. Halberg (Eds.), *Adapting*

instruction to individual differences (pp. 82-90). Berkeley, CA: McCutchan.
This chapter comments on two recurring themes in this volume: the range of variables that makes for the complexities of learning and teaching and the need for research on the noncognitive aspects of learning that play an essential role in the acquisition of skill and knowledge through schooling. [Topics: 1, 16] 1985-012

Glaser, R. (1985). Foreword. In R. C. Anderson, E. H. Hiebert, J. A. Scott, & I. A. G. Wilkonson (Eds.), *Becoming a nation of readers: The report of the commission on reading* (pp. v-viii). Pittsburgh, PA: National Academy of Education.
This foreword to a national report on reading surveys the research that set the stage for the report. [Topics: 1, 12] 1985-013

Glaser, R. (1985). Learning and instruction: A letter for a time capsule. In S. F. Chipman, J. W. Segal, & R. Glaser (Eds.), *Thinking and learning skills: Research and open questions* (Vol. 2, pp. 609-618). Hillsdale, NJ: Erlbaum.
This chapter in a volume of articles on the development of higher order thinking skills examines issues in research on subject matter learning and debates about instruction that were characteristic of the late 1970s and early 1980s. [Topics: 1, 6] 1985-014

Glaser, R. (1985). Understanding human intelligence [Review of *Beyond IQ*]. *Science, 230*, 59-61.
This review of Robert Sternberg's *Beyond IQ* praises the book's account of intelligence, which considers experiential and contextual aspects as well as cognitive processes, but finds that the account falls short of a fully integrated theory. In particular, new theories of human mental capacities must attend to advances in developmental psychology since Piaget. [Topic: 6] 1985-015

Glaser, R. (1986). Intelligence as acquired proficiency. In R. J. Sternberg & D. K. Detterman (Eds.), *What is intelligence? Contemporary viewpoints on its nature and definition* (pp. 77-83). Norwood, NJ: Ablex.
Intelligence as acquired proficiency in intellectual cognitive performances is the topic of this chapter. Two types of performance, artifactually constrained proficiency and naturally constrained proficiency, influence the characteristics of intelligence performances. So viewed, intelligence is trainable and amenable to support, and its limits can be delineated. [Topics: 6, 16] 1986-006

Glaser, R. (1986). On the nature of expertise. In F. Klix & H. Hagendorf (Eds.), *Human memory and cognitive capabilities: Mechanisms and performances* (pp. 915-928). Amsterdam, the Netherlands: Elsevier Science Publishers.
Studies show that high levels of competence result from the interaction between knowledge structures and processing abilities. Expert performance is characterized by rapid access to an organized body of conceptual and procedural knowledge. Propositions are presented in this chapter that summarize findings confirming this view. [Topic: 13] 1986-007

Glaser, R. (1986). The integration of instruction and testing. In E. Freeman (Ed.), *The redesign of testing in the twenty-first century: Proceedings of the 1985 ETS Invitational Conference* (pp. 45-58). Princeton, NJ: Educational Testing Service.
Cognitive psychology makes possible methods of achievement testing that index stages of competence by monitoring the development of specific knowledge, skills, and cognitive processes. This article describes the theoretical advances that can inform the design of tests that capture changes in performances and that can be integral to instruction. [Topics: 3, 16] 1986-008

Glaser, R. (1986). *Training expert apprentices* (Learning Research Laboratory: Proposed research issues. AFHRL-TP-85-54). Brooks Air Force Base, TX: Air Force Human Resources Laboratories.
Encouraging the capabilities that can enable trainees to learn from subsequent workplace experiences is a core aim of many training programs. The objectives appropriate to this aim are being specified in studies of the dimensions along which expertise develops. This article offers recommendations on how understanding of these dimensions can guide instruction and research on training. [Topics: 13, 18] 1986-009

Glaser, R. (1987). A cognitive science perspective on selection and classification and on technical training. In T. Sticht, F. Chang, & S. Wood (Eds.), *Advances in reading/language research* (Vol. 4, pp. 253-268). Greenwich, CN: JAI Press.
Examination of the contributions of advances in the study of human cognition to research on military performance raises the question of the potential application of new concepts to the tasks of selection and classification, as well as to technical training. [Topics: 3, 18] 1987-015

Glaser, R. (1987). Introduction: Further notes toward a psychology of instruction. In R. Glaser (Ed.), *Advances in instructional psychology* (Vol. 3, pp. vii-xxv). Hillsdale, NJ: Erlbaum.
This introduction to a volume assembling contributions from leading researchers treats major themes in studies of reading, mathematics learning, and cross-cultural analyses of classroom practices. [Topics: 1, 5a, 5c] 1987-016

Glaser, R. (1987). Learning theory and theories of knowledge. In E. DeCorte, J. G. L. C. Lodewijks,

R. Parmentier, & P. Span (Eds.), *Learning and instruction* (pp. 397-414). Oxford/Leuven: Pergamon Press/Leuven University Press.
Acquired knowledge and reasoning skills, especially the organized knowledge evident in proficient performers' problem representation, are the focus of this discussion. The ways that both the artifactual knowledge structures of subject-matter disciplines and the natural knowledge structures studied by developmental psychologists facilitate learning are examined. [Topics: 2, 5a, 5b] 1987-017

Glaser, R. (1987). The integration of instruction and testing: Implications from the study of human cognition. In D. C. Berliner & B. V. Rosenshine (Eds.), *Talks to teachers* (pp. 329-341). New York: Random House.
This chapter's theme is that learning assessments (tests) should not provide merely a score, a label, a grade level, or a percentile, but also instructional scoring that makes apparent the requirements for increasing competence. [Topics: 1, 3] 1987-018

Glaser, R. (1987). The study of cognition and instructional design: Mutual nurturance. *Behavioral and Brain Sciences, 10*, 483-484.
This commentary on John R. Anderson's *Methodologies for Studying Human Knowledge* supports the argument for research on learning at the algorithmic level of analysis and adds that the development of learning theory will also require study of implementation processes that produce the behaviors that new learning theories claim to describe. [Topic: 1] 1987-019

Glaser, R. (1987). Thoughts on expertise. In C. Schooler & W. Schaie (Eds.), *Cognitive functioning and social structure over the life course* (pp. 81-94). Norwood, NJ: Ablex.
In recent years, cognitive psychologists have investigated human performances that are acquired over long periods of learning and experience. These studies have contrasted the knowledge and skill of experts with that of novices. The generalizations presented in this chapter summarize current findings on the nature of expertise. [Topic: 13] 1987-020

Glaser, R. (1988). Cognitive science and education. *International Social Science Journal, 40*(1), 21-44.
This article examines the current state of the relationship between cognitive science and education by focusing on two areas of investigation: the analysis of the competence (knowledge and skill) acquired in different subject-matter domains and theoretically grounded approaches to designing conditions for learning and instructional interventions that reflect advancing knowledge of competence. [Topics: 1, 5a, 5b, 5c, 5d] 1988-010

Glaser, R. (1988). Commentary: Cognitive and environmental perspectives on assessing achievement. In E. Freeman (Ed.), *Assessment in the service of learning: Proceedings of the 1987 ETS Invitational Conference* (pp. 37-44). Princeton, NJ: Educational Testing Service.
The challenge in developing new forms of testing that reflect advances in knowledge of human cognition will be to mesh cognitive and environmental perspectives. The first allows the development of instruments that can measure progress along well-defined dimensions of competence; the second encourages attention to notions of achievement that are enabling and support future performances. [Topics: 1, 3] 1988-011

Glaser, R. (1989). Expertise and learning: How do we think about instructional processes now that we have discovered knowledge structures? In D. Klahr & K. Kotovsky (Eds.), *Complex information processing: The impact of Herbert A. Simon* (pp. 269-282). Hillsdale, NJ: Erlbaum.
This essay comments on the impact of cognitive analyses of human performance on the design of new forms of instruction. Citing programs that aim to produce specific competencies that have been described in key studies of the past two decades, the discussion turns to research on experts' rapid pattern recognitions and representational abilities. The focus here is the possibilities that lie in studies of effective self-elaboration of problems for revealing ways to foster quick acquisition of these tactics. [Topics: 1, 13] 1989-026

Glaser, R. (1989). Knowledge-derived competence. In K. W. Schaie & C. Schooler (Eds.), *Social structure and aging: Psychological aspects* (pp. 113-120). Hillsdale, NJ: Erlbaum.
This commentary on a conference paper on the Seattle Longitudinal Study data base, which describes cognitive changes with age for birth cohorts, argues that heuristic processes are only part of individual variation in cognitive proficiency and that much else resides in domain-specific processes that have been nurtured over the course of life-span development. [Topic: 2] 1989-027

Glaser, R. (1990). Expert knowledge and the thinking process. *Chemtech, 20*, 394-397.
This article is an account in a professional magazine for chemists of the general characteristics of expertise. The implications of research on expert performance for instruction are also discussed. [Topics: 1, 13] 1990-020

Glaser, R. (1990). Expertise. In M. W. Eysenck, A. Ellis, & E. Hunt (Eds.), *The blackwell dictionary of cognitive psychology* (pp. 139-140). Oxford, England: Basil Blackwell.
Studies of experts' problem solving, in domains ranging from physics, medical diagnosis, computer programming, skilled memory, and mental calculation to taxi driving and typing have produced generalizable findings that permit characterization of expertise along well-defined lines. Across the results, specialized knowledge shaped experts' performances in ways that indicate that certain features of performance are typical of high levels of proficiency. [Topic: 13] 1990-021

Glaser, R. (1990). Expertise and assessment. In M. C. Wittrock (Ed.), *Cognition and testing*. Englewood Cliffs, NJ: Prentice Hall.
Studies of expertise have investigated the nature of the knowledge and cognitive processes that underlie developing competence in various domains of learning. Findings on the nature of expertise can serve as a basis for integrating cognitive theory with psychometric techniques in the design of achievement tests that assess growing proficiency in subject-matter learning. [Topics: 3, 13] 1990-081

Glaser, R. (1990). *Testing and assessment: O tempora! O mores!* Paper presented at the Horace Mann lecture at the University of Pittsburgh, Pittsburgh, PA.
Trends, over the course of this century, in testing and in assessment are sketched to trace the influences of past techniques and traditions on current practices. The use of assessments of achievement as general educational indicators has kept them decoupled from instructional systems and not well suited to providing useful feedback for learning and teaching. Principles and practices that are emerging for integrating testing and instruction are considered. [Topics: 3, 16] 1990-022

Glaser, R. (1990). The reemergence of learning theory within instructional research. *American Psychologist, 45*(1), 29-39.
Instructional programs that aim to produce specified forms of competence are of increasing value to the interactive growth of learning theory and its applications. Four such programs are reviewed here. Approaches to future integration of various principles of learning in the design of conditions that foster the acquisition of key components of competence are discussed. [Topics: 1, 2] 1990-023

Glaser, R. (1990). Toward new models for assessment. *International Journal of Educational Research, 14*(5), 475-483.
The results of assessments of student achievement strongly influence how students assess themselves, what they aspire to, and how much effort they put into their activities. Unless we examine the impact of assessments and consider new approaches to their design, we neglect a major opportunity to improve education. [Topics: 1, 3] 1990-024

Glaser, R. (1991). Intelligence as an expression of acquired knowledge. In H. A. H. Rowe (Ed.), *Intelligence: Reconceptualization and measurement* (pp. 47-56). Hillsdale, NJ: Erlbaum.
This chapter proposes a conception of intellectual proficiency that rests on advances in our understanding of the acquisition of knowledge, the characteristics of expertise, and performance in unfamiliar domains. On the view that learning and experience are central to intelligence, it discusses dimensions of competence that can serve as a basis for assessing the growth of intellectual proficiency. [Topics: 1, 3] 1991-019

Glaser, R. (1991). The maturing of the relationship between the science of learning and cognition and educational practice. *Learning and Instruction* (Vol. 1, pp. 129-144). Great Britain: Pergamon Press.
Several lines of instructional research suggest that a strong and mutually beneficial relationship is evolving between studies of learning and innovative programs of instruction. A set of representative programs in major areas of inquiry is discussed. [Topics: 1, 5b, 5c] 1991-080

Glaser, R. (Ed.). (1987). *Advances in instructional psychology* (Vol. 3). Hillsdale, NJ: Erlbaum.
This volume brings together reports of leading researchers' investigations of instructional psychology. Chapters by John Fredricksen and Beth Warren, Lauren Resnick and Susan Omanson, Robert Sternberg, and Harold Stevenson and his colleagues have been assembled. [Topics: 2, 5a, 5c, 16] 1987-021*

Glaser, R., & Bassok, M. (1989). Learning theory and the study of instruction. In M. R. Rosenzweig & L. W. Porter (Eds.), *Annual review of psychology* (Vol. 40, pp. 631-666). Palo Alto, CA: Annual Reviews.
Two decades of intensive cognitive science research on competence have yielded grounds and methods for new approaches to building a cognitive theory of learning. The reemergence of learning theory is discussed through analysis of four representative programs of research on instructional intervention. Analytic accounts are given of the principles that guided the design of

a program for developing procedural skill, a program for fostering metacognition, a program facilitating the use of mental models, and a program for training the inference processes needed to build organized knowledge. [Topics: 1, 3, 16] 1989-028

Glaser, R., & Chi, M. T. H. (1988). Overview. In M. T. H. Chi, R. Glaser, & M. J. Farr (Eds.), *The nature of expertise* (pp. xv-xxviii). Hillsdale, NJ: Erlbaum.
In recent years, research on expertise has examined performances that are based on hundreds and thousands of hours of learning and experience. These studies of expertise in knowledge rich domains, together with theories of competent performance and attempts at the design of expert systems, have sharpened the contrast between novice and expert performances in showing strong interactions between structures of knowledge and processes of reasoning to be essential to highly proficient performance. This volume assembles reports of major advances in research in this area. [Topics: 2, 9, 13] 1988-012

Glaser, R., & Pellegrino, J. W. (1987). Aptitudes for learning and cognitive processes. In F. Weinert & R. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 267-288). Hillsdale, NJ: Erlbaum.
This summary report of research attempts to identify directly the cognitive processing components of performance on tasks used to assess aptitude. The immediate goal is to analyze test tasks, develop process models of task performance, and utilize these models as a basis for describing individual differences. The ultimate goal is to use the knowledge gained to design conditions for learning that could be adjusted to these individual characteristics. [Topics: 3, 13] 1987-022

Glaser, R., & Takanishi, R. (Eds.). (1986). Introduction: Creating a knowledge base for education: Psychology's contributions and prospects. *American Psychologist, 41*(10), 1025-1028.
This introduction to a special issue on education of the American Psychologist discusses major advances in research on learning, teaching, and classroom practices, as well as on training, assessment, and other educational processes. [Topics: 1, 3, 7] 1986-010

Glaser, R., Lesgold, A., & Lajoie, S. (1987). Toward a cognitive theory for the measurement of achievement. In R. R. Ronning, J. Glover, J. C. Conoley, & J. C. Witt (Eds.), *The influence of cognitive psychology on testing and measurement* (pp. 41-85). Hillsdale, NJ: Erlbaum.
This chapter argues that achievement measurement should be based on advanced knowledge of learning and of the course of acquisition of competence in subject matters. It suggests a set of cognitive principles to guide the design of measures of achievement. [Topics: 3, 18] 1987-023

Glaser, R., Raghavan, K., & Schauble, L. (1988). Voltaville, a discovery environment to explore the laws of dc circuits. *Proceedings of the 1988 International Conference on Intelligent Tutoring Systems* (pp. 61-66). Montreal, Canada: University of Montreal.
VOLTAVILLE is the initial prototype of a discovery environment designed to foster skills of scientific inquiry. In the context of learning principles of D.C. electric circuits, students conducted experiments and protocols were taken of their effective strategies and their misconceptions. The significance of the results to deepening understanding of science learning and to advances in instruction are explored. [Topics: 1, 5b] 1988-013

Gobbo, C., & Chi, M. T. H. (1986). How knowledge is structured and used by expert and novice children. *Cognitive Development, 1*, 221-237.
This research contrasts the knowledge structures of expert and novice children in the domain of dinosaurs, as well as how this knowledge is used. Several measures were developed to assess differences in knowledge structures, such as how frequently children use connecting words in their production protocols, and the frequency with which they switch topics in their discussion of a dinosaur. How children use their knowledge was assessed by measures such as the frequency with which they infer new implicit information or make semantic comparisons about unknown dinosaurs. These differences in the structure and use of knowledge suggest that expert children can better use and access their knowledge than novice children because it is more cohesive and integrated. [Topics: 2, 11, 13] 1986-011

Gott, S., & Glaser, R. (1985). *Cognitive components of expertise and the transfer of training*. Brussels, Belgium: Learning Research Laboratory, NATO.
This report discusses the impact of psychological advances in studies of expertise for transfer of technical training skills. Analysis of components of expert performance can be useful to understanding how knowledge is acquired and adaptive skill is generated. [Topics: 13, 18] 1985-016

Gott, S., Lesgold, A. M., & Glaser, R. (1987). Implications of cognitive psychology for measuring job performance. In H. G. Baker & G. J. Laabs (Eds.), *Proceedings of the Department of Defense/Educational Testing Service Conference on Job*

Performance Measurement Technologies (pp. 37-48). Washington, DC: Office of the Assistant Secretary of Defense.

To produce useful prescriptions for training complex cognitive skills, detailed assessments, guided by cognitive theories of performance, are necessary. This article presents a study showing that performance measures used as diagnostic inputs to training can lead to impressive gains in skills. [Topics: 3, 18] 1987-024

Gregg, M., & Stainton, C. (1991). *Geography in the news: Word-level coding manual* (Tech. Rep. No. CLIP-91-02). Pittsburgh, PA: University of Pittsburgh, LRDC.

This report is a word-level coding manual for geographic references found in text. Eleven categories account for words or phrases that name or provide specific or generic geographic information. Operational definitions and examples are provided for each category, subcategory, and sub-subcategory to illustrate the constraints of each. [Topics: 5d, 15] 1991-020

Gregg, M., Stainton, C., & Leinhardt, G. (1990). *Where is geography? Three studies of thinking and teaching* (Tech. Rep. No. CLIP-90-04). Pittsburgh, PA: University of Pittsburgh, LRDC.

Three studies of geographic literacy were conducted in order to begin to assess both the demands for geographic knowledge placed on adults in our society and the school-based opportunities for acquiring this knowledge. By using analytic tools from cognitive psychology to code and analyze data from three sources, the authors are able to draw some conclusions about the structure of people's geographic knowledge and to provide some curricular recommendations. [Topics: 5d, 6, 16] 1990-025

Griffey, Q. L., Zigmond, N., & Leinhardt, G. (1988). The effects of self-questioning and story structure training on the reading comprehension of poor readers. *LD Research*, 4(1), 45-51.

This study investigates the effectiveness of self-questioning and story structure training on reading comprehension. Three complete elementary learning disabilities classes were assigned randomly to one of three experimental groups. The first group received instruction in self-questioning to identify the main character in a narrative story, the aim of the story, the problem encountered in the story, and the problem's solution. A second group received training in story structure identification without self-questioning training. The third group received no strategy training. Analyses revealed that the combined self-questioning and story structure group correctly answered significantly more comprehension questions than the group that received no strategy training. [Topic: 17] 1988-014

Grover, B. W., Zaslavsky, O., & Leinhardt, G. (1989). *An approach to the design and development of a scoring system for a new teacher assessment: The semi-structured interview* (Tech. Rep. No. CLIP-89-02). Pittsburgh, PA: University of Pittsburgh, LRDC.

This report describes an approach to the design and development of a scoring system for one of the new content-based assessments that reflect the intricacy and complexity of teaching. The assessment is a semi-structured interview for secondary mathematics teachers designed as part of a state's licensing procedures. The scoring system converts the open-ended, verbal responses of candidates into an assessment on four general dimensions of teaching as well as four specific tasks. [Topic: 3] 1989-029

Gupta, P., & Schneider, W. (1991). Attention, automaticity, and priority learning. *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society* (pp. 534-539). Hillsdale, NJ: Erlbaum.

This article proposes a priority learning mechanism to model the effects of practice and the development of automaticity, in visual search tasks. A connectionist simulation model implements this learning algorithm. Five prominent features of visual search practice effects are simulated. These are: 1) in consistent mapping tasks, practice reduces processing time, particularly the slope of reaction times as a function of the number of comparisons; 2) in varied mapping tasks, there is no change in the slope of the reaction time function; 3) both the consistent and varied effects can occur concurrently; 4) reversing the target and distractor sets produces strong interference effects; and 5) the benefits of practice are a function of the degree of consistency. [Topic: 19] 1991-021

Hall, N., & Ohlsson, S. (1991). A theory of manipulatives in arithmetic learning. In L. Birnbaum (Ed.), *Proceedings of the International Conference of the Learning Sciences* (pp. 217-221). Chicago: Northwestern University.

Educators frequently recommend a teaching scenario for arithmetic in which an arithmetic procedure is first explained in terms of an embodiment. The authors explain the workings of this teaching scenario in terms of three learning mechanisms: proceduralization, analogical procedure construction, and simplification. Their theory predicts that a major determinant of the pedagogical effectiveness of this teaching scenario

is the degree of isomorphism between the embodiment procedure and the expanded procedure. The authors introduce a method for quantifying this relation. The measure can be used descriptively, to explain why particular instances of the scenario are not pedagogically effective. They also apply the measure prescriptively, as a tool for searching the design of embodiments. [Topic: 5a] 1991-022

Hanson, V. L., Goodell, E. W., & Perfetti, C. A. (1991). Tongue-twister effects in the silent reading of hearing and deaf college students. *Journal of Memory and Language, 30*, 319-330.
The fact that normal readers use phonology supports the hypothesis that phonological processes are used pre-lexically and automatically for word identification. That "good" deaf readers also seem to be using phonological processes lends further support to the notion that phonological codes are automatically used in word identification. [Topic: 12] 1991-023

Hativa, N., Sarig, O., & Lesgold, A. (1991). Timing students' answers in CAI. *Journal of Computer-Based Instruction, 18*(1), 19-29.
This article investigated results of increasing allowed response time in a computer-based practice system for elementary-school arithmetic. In the first 2 months after allowed response time was increased, all students, but especially the lower achievers, improved their performance. Those who initially made a large proportion of errors benefitted the most. [Topic: 7] 1991-024

Johnston, J. A., Bickel, W. E., & Wallace, R. C. Jr. (1990). Building and sustaining change in the culture of secondary schools. *Educational Leadership, 47*(8), 46-48.
Using data from the Schenley High School Teacher Center (SHTC) program, effective strategies for restructuring the influence of urban high schools are described. [Topic: 4] 1990-026

Jones, R. M., & VanLehn, K. (1991). Strategy shifts without impasses: A computational model of the sum-to-min transition. *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society* (pp. 358-363). Hillsdale, NJ: Erlbaum.
The Sum-to-Min transition that children exhibit when learning to add provides an ideal domain for studying naturally occurring discovery processes. The authors discuss a computational model that accounts for this transition, including the appropriate intermediate strategies. In order to account for all of these shifts, the model must sometimes learn without the benefit impasses. The described model smoothly integrates impasse-driven and impasse-free learning in a single, simple learning mechanism. [Topic: 5a] 1991-025

Jones, R., & VanLehn, K. (1991). A computational model of acquisition for children's addition strategies. In L. Birnbaum & G. Collins (Eds.), *Machine learning: Proceedings of the Eighth International Workshop* (pp. 65-69). San Mateo, CA: Morgan Kaufmann.
GIPS is a problem-solving system that models the strategy shifts of children learning to add. The system uses a generalized form of mean-ends analysis as its reasoning algorithm, and it learns probabilistic selection and execution concepts for its operators. With this combination, GIPS models the SUM-to-MIN transition that children exhibit when learning to add. The system generates the appropriate final strategy, as well as the intermediate strategies that Siegler and Jenkins (1989) observed. [Topic: 5a] 1991-026

Kearns, L. R. (1991). Distributed computing support: Buying and selling it wholesale. *Proceedings of the ACM SIGUCCS User Services Conference XIX* (pp. 165-169). New York: Association for Computing Machinery, Inc.
One model for providing distributed computing support to academic departments on campuses is based on the concept of a departmental consultant, i.e., a person or group of people working within a department who supports the computing functions of that department and acts as liaison with the campus computing center. This article describes how the limitations of centralized service to the user population of academic professionals can be overcome by using the departmental consultant model and offers suggestions to campus computing centers for making the best use of that model. [Topic: 7] 1991-027

Keith, W. K., Weiner, A. W., & Lesgold, A. M. (1991). Toward computer-supported instruction of argumentation. In F. H. van Eemeren, R. Grootendorst, J. A. Blair, & C. Willard (Eds.), *Proceedings of the Second International Conference on Argumentation* (1B, pp. 1144-1156). Amsterdam, the Netherlands: International Society for the Study of Argumentation.
This article suggests an apprenticeship model of teaching of argumentation, which could be supported by a computer practice environment. [Topics: 6, 7] 1991-028

Keith, W., Weiner, A., & Lesgold, A. (1989). Argument comprehension: Some preliminary findings. In B. E. Gronbeck, R. S. Bjork, D. S. Gouran, D. W. Parson, & M. O. Sillars (Eds.), *Spheres of argument: Proceedings of the Sixth SCA/AFA Conference on Argumentation* (pp. 584-591). Annandale, VA: Speech Communication Association.

Based on preliminary reports of empirical studies, it appears that in constructing an interpretation of an argument in a text, subjects bring surface and deep schemas to construct, not a logical structure, but an intermediate argument representation, which includes information about the speaker's purpose and the situation as well as the propositional content of the text. The IAR concept may be extended to represent dialogic engagement. [Topic: 6] 1989-030

Kerr, M. M., & Zigmond, N. (1986). What do high school teachers want? A study of expectations and standards. *Education & Treatment of Children*, 9(3), 239-249.

The study reported in this article investigated the classroom standards and expectations held by high school regular and special educators. Two hundred twenty regular educators and 24 special educators completed the SBS Inventory of Teacher Social Behaviors Standards and Expectations (SBS) (Walker & Ranking, 1980). Results indicated that both groups of educators gave highest priority to behaviors reflecting good academic performance, study habits, and classroom deportment, while deemphasizing students' interpersonal skills and problems. Regular educators were more rigorous than special educators in their expressed standards. In general, the results were similar to those described for elementary school teachers (Walker & Rankin, 1983). [Topic: 17] 1986-012

Kerr, M. M., Zigmond, N., Harris, A. L., & Brown, G. M. (1986). An observational follow-up of successful and unsuccessful high school students. *The High School Journal*, *70*(1), 20-24.

One of the fundamental problems in the development of secondary school programs for special education students is the failure on the part of researchers to conduct a thorough, systematic analysis of the performance deficits of the students enrolled. To date, there has been no comprehensive behavioral analysis of those skills which enable a student to function competently at the high school level. Rather, researchers have relied upon literature reviews, expert judgments, and/or problems referred to their particular educational program. This a priori approach to target behavior selection is questionable. [Topic: 17] 1986-013

Klopfer, L. E. (1986). *Academic preparation in science: Teaching for transition from high school to college*. New York: College Entrance Exam Board.

In conjunction with the Science Advisory Committee to the College Entrance Examination Board's Educational EQuality Project, the author composed an optimistic guidebook for high school teachers delineating how important science knowledge and experiences with scientific inquiry can become accessible to virtually all students through properly designed instruction. The suggestions for developing and utilizing appropriate instructional strategies, as well as the specific illustrations offered in this guide,are grounded in the contemporary cognitive research on students' alternative conceptions, the elements of scientific thinking, and the development of science understanding. [Topic: 16] 1986-014*

Klopfer, L. E. (1986). Intelligent tutoring systems in science education: The coming generation of computer-based instructional programs. *Journal of Computers in Mathematics and Science Teaching*, 5(4), 16-32.

Responding to widely heralded contemporary concerns about the failure of students to learn science subject-matter effectively, the author launches a double-barreled exploration of the potential alleviation of this problem by utilizing computer-based instructional programs. In the first section, the author surveys the present status in the U.S. of science instructional software for use on microcomputers in schools. Accompanying this is an exemplary instrument for evaluating science software. The second section discusses some of the current work at the University of Pittsburgh's Learning Research and Development Center on the development of intelligent tutoring systems, through which the dream of providing compelling and effective science learning experiences can be fulfilled. [Topic: 5b] 1986-015

Klopfer, L. E. (1986). Resources for research on science education in Japan. *Science Education*, *70*(3), 347-350.

Although Japan is widely thought to have successful science education programs, hardly any serious studies exist that would enable U.S. educators to understand the character, organization, purposes, and methods of science teaching in Japanese schools. To begin to address the need for better understanding of science teaching in Japan, the author prepared this resource guide for both English language publications concerning science education and Japanese science education periodicals. [Topic: 1] 1986-016

Klopfer, L. E. (1986). The coming generation of tutoring software. *The Science Teacher*, 56(8), 34-37.

Since the great majority of presently available science software for microcomputers is disappointing in quality, pedagogically naive, and mundane, many science teachers are not utilizing computers in their teaching. This unsatisfactory state of affairs may change as the next generation of instructional software comes into science

education. The new tutoring software now being developed by researchers will offer practical systems that work like master teachers to tailor instruction to students' individual needs. The intelligent tutoring programs, together with affordable computer hardware to run them, could be available for use in science classrooms within about five years. Whether or not science teachers will be ready to embrace the coming generation of tutoring software when it arrives remains an open question. [Topic: 16] 1986-017

Klopfer, L. E. (1990). Learning scientific enquiry in the student laboratory. In E. Hagerty-Hazel (Ed.), *The student laboratory and the science curriculum* (pp. 95-118). London: Routledge.

In planning student laboratory work, science educators need to design or choose experiences that provide opportunities for students to utilize enquiry skills. In addition to such implicit teaching, there should be explicit teaching about enquiry. Scientific enquiry outcomes from laboratory work are discussed and illustrated in this chapter under five broad headings, covering both the experimental phase of enquiry and the formulation of scientific laws, priciples, and theories. While these desired outcomes can be specified in considerable detail, the question remains as to whether it is reasonable to expect all students in any school environment to attain them. [Topic: 16] 1990-027

Klopfer, L. E. (1991). *An historical perspective on the history and nature of science in school science programs.* Colorado Springs, CO: Biological Sciences Curriculum Study.

Interest in utilizing the history and philosophy of science in school science programs is blossoming again. Some knowledge about previous efforts to infuse science teaching with materials on the history and nature of science can provide the new enthusiasts with valuable suggestions and cautions. That historical perspective is furnished in this report. [Topic: 16] 1991-029

Klopfer, L. E., & Champagne, A. B. (1990). Ghosts of crisis past. *Science Education, 74,* 133-154.

It appears to be fashionable in science education in the U.S. to have recurring cycles where a serious crisis is first recognized and a major curricular reform effort then follows. Such a cycle is now in progress, but the previous crisis' ghosts still haunt us. After a crisis in science education became apparent in the late 1950's, national science curriculum reform projects were launched at the high school, elementary school, and junior high school levels. This article reviews and documents the numerous programs that appeared on the scene through the mid-1970's. Few of these programs survived for very long. Moreover, the cause of teaching science for the purpose of general education--Science for All! in today's parlance--was not particularly well served in the last crisis cycle. [Topic: 1] 1990-028

Kohn, A. S., & Landau, B. (1990). A partial solution to the homonym problem: Parents' linguistic input to young children. *Journal of Psycholinguistic Research, 19,* 71-89.

Fifteen parents described pictured sets of concrete object homonyms and categorically related objects to their young children. Parents described homonyms by using explicit statements of category inclusion, subordinate forms (compounds, e.g., kiwi-bird), and specific forms that flagged the unusual homonym relationship. Parents especially provided distinctive alternating forms for homonym pairs (e.g., iceskate vs. skate-fish) suggesting that they were attempting to preserve the unique form-meaning relationship violated by homonyms. The authors discuss how such linguistic information might be used by children to differentiate homonyms. [Topics: 2, 10, 12] 1990-029

Kouba, V. L., Brown, C. A., Carpenter, T. P., Lindquist, M. M., Silver, E. A., & Swafford, J. O. (1988). Results of the fourth NAEP Assessment of Mathematics: Measurement, geometry, data interpretation, attitudes and other topics. *Arithmetic Teacher, 35,* 10-16.

This article is the second of three articles to appear in the Arithmetic Teacher reporting the third-grade and seventh-grade results of the fourth mathematics assessment of the National Assessment of Educational Progress (NAEP). This article reports students' performance on measurement, geometry, data organization and interpretation, variables and relations, and attitudes. Four general conclusions emerged from the analysis: 1) Students perform better on familiar items than on unfamiliar items; 2) Students perform better on simple items than on more complex or non-routine items; 3) Many students demonstrate a lack of understanding of underlying concepts; and 4) Students perform better on items that can be solved visually than those which require more abstract thinking. [Topics: 3, 5a] 1988-015

Kouba, V. L., Brown, C. A., Carpenter, T. P., Lindquist, M. M., Silver, E. A., & Swafford, J. O. (1988). Results of the fourth NAEP Assessment of Mathematics: Number, operations, and word problems. *Arithmetic Teacher, 35,* 14-19.

This article is the first of three articles to appear in the Arithmetic Teacher reporting the third-grade and seventh-grade results of the fourth

mathematics assessment of the National Assessment of Educational Progress (NAEP). This article summarizes major results of the performance on number, operations, and word-problem items. Students experienced difficulty with items that did not involve routine, familiar tasks. Evidence is cited to support the view that mathematics learning for most U.S. students seems to be taking place at the rote manipulation level without understanding of underlying concepts. [Topics: 3, 5a] 1988-016

Kramer, A., Schneider, W., Fisk, A., & Donchin, E. (1986). The effects of practice and task structure on components of the event-related brain potential. *Psychophysiology, 23*(1), 33-47.
This study focused on the effects of, and the interactions between, practice and task structure on human performance. Development of automatic processing through consistent stimulus-response mapping (CM) was assessed by means of measures of reaction and event-related brain potentials. The variables manipulated in the study included number of memory set items, task structure, and probability of occurrence of a memory set item. Set size had a significant effect on RT in both CM and VM conditions prior to practice and in the VM condition following extensive practice. The commonly observed relationship between probability and P300 amplitude, with larger P300s elicited by infrequent events, was found in the VM conditions but not in the CM conditions after practice. [Topic: 19] 1986-018

Kratzer, L., & Nelson-Le Gall, S. (1990). Understanding competencies and limitations of wheelchair-bound peers as helpers: Developmental changes during early childhood. *Journal of Applied Developmental Psychology, 11*, 69-84.
Nonhandicapped children in kindergarten through third grade were presented with stories about classroom tasks in which a nonhandicapped child could ask for help from either a wheelchair-bound child or a nonhandicapped child. Findings suggest that children's understanding of physical handicaps develops gradually over the early childhood years with an important change occurring at first grade; namely, children begin to differentiate between limitations and competencies of handicapped children. The results are discussed in the context of developmental changes in children's social-cognitive knowledge and social reasoning from early to middle childhood. [Topics: 6, 14] 1990-030

LaJoie, S. P., & Lesgold, A. (1989). Apprenticeship training in the workplace: Computer-coached practice environment as a new form of apprenticeship. *Machine-Mediated Learning, 3*, 7-28.
Air Force technicians who practice with SHERLOCK, a computer-based coached practice environment, show marked improvement in difficult troubleshooting skills. SHERLOCK's strategy is to provide holistic practice in a realistic context, supported by tailored coaching on request. This article compares the SHERLOCK approach to other recent cognitive apprenticeship proposals. [Topics: 7, 18] 1989-031

Lam, A., Perfetti, C. A., & Bell, L. (1991). Automatic phonetic transfer in bidialectal reading. *Applied Psycholinguistics, 12*, 299-311.
This article reports evidence for phonological activation in reading a non-alphabetic script--Chinese. Two dialects, Mandarin and Cantonese, have different pronunciations (different words actually) for a given Chinese character. The study exploited this fact in a speeded similarity judgement task. When subjects were to make their judgements based on Mandarin, the pronunciation of the subjects' primary Cantonese dialect interfered with judgements. The conclusion is that the phonological information, the name of the character, is difficult to suppress even in reading a nonalphabetic script. [Topic: 12] 1991-030

Langley, P., Wogulis, J., & Ohlsson, S. (1990). Rules and principles in cognitive diagnosis. In N. Frederiksen, R. Glaser, A. Lesgold, & M. G. Shafto (Eds.), *Diagnostic monitoring of skill and knowledge acquisition* (pp. 217-250). Hillsdale, NJ: Erlbaum.
Cognitive diagnosis is the process of inferring what a person knows from a record of his/her behavior. The automatization of cognitive diagnosis is necessary to provide intelligent tutoring systems with the capability of giving individualized instruction. Two methods for automatized cognitive diagnosis are presented in this chapter. The first method uses information from a sequence of behaviors to successively focus the diagnosis. The second method infers conceptual knowledge by noticing violations of domain-specific constraints. [Topics: 3, 6] 1990-031

LeMahieu, P., & Leinhardt, G. (1985). Overlap: Influencing what's taught. A process model of teachers' content selection. *Journal of Classroom Interaction, 21*(1), 2-11.
This article reviews the mechanism by which overlap affects instructional content. The authors describe the concept of overlap between instruction and assessment and the potential influence of tests on teachers' curricular content choices. [Topics: 3, 4, 16] 1985-017

Leinhardt, G. (1985). Instructional time: A winged chariot? In C. W. Fisher & D. C. Berliner (Eds.), *Perspectives on instructional time* (pp. 263-282). New York: Longman Press.
The use of instructional time in classroom research is traced in a series of three major field studies--one focusing on student achievement, a second on opportunity to learn, and a third on measures of instructional process. These studies demonstrate several important developmental trends in the use of time as a metric in classroom research and the author presents six basic findings from research on instructional time. [Topics: 3, 4, 16] 1985-018

Leinhardt, G. (1986). Expertise in mathematics teaching. *Educational Leadership*, 43(7), 28-33.
Findings from a contrastive study of expert and novice elementary mathematics teachers are reviewed and examples from one expert's teaching are used to discuss elements of expertise. These elements include maximizing time usage and content coverage; using effective routines and activity structures in constructing lessons; developing meaningful, content-based agendas for lessons; and providing rich explanations that build on students' prior knowledge, use well known representations to introduce new material, provide complete demonstrations, and prove the legitimacy of the new concept or procedure. [Topics: 13, 16] 1986-019

Leinhardt, G. (1988). Expertise in instructional lessons: An example from fractions. In D. A. Grouws & T. J. Cooney (Eds.), *Perspectives on research on effective mathematics teaching* (pp. 47-66). Hillsdale, NJ: Erlbaum.
This chapter describes major components of expertise in the teaching of elementary mathematics, drawing primarily on findings from a contrastive study of novice and expert teachers teaching fractions. Lesson segments, routines, scripts, agendas, and explanations are described and a model of an expert explanation of specific subject matter is presented. [Topics: 5a, 13, 16] 1988-017

Leinhardt, G. (1988). Getting to know: Tracing students' mathematical knowledge from intuition to competence. *Educational Psychologist*, 23(2), 119-144.
This article describes four different classes of student knowledge in mathematics--intuitive, concrete, computational, and conceptual. Based on observations and interviews with teachers and students in the classrooms of two expert elementary mathematics teachers, a detailed portrait is provided of how the different types of knowledge interacted and evolved in these children over time, resulting in their own understanding. Suggestions for future research are also presented. [Topics: 2, 5a, 16] 1988-018

Leinhardt, G. (1988). Situated knowledge and expertise in teaching. In J. Calderhead (Ed.), *Teachers' professional learning* (pp. 146-168). London: Falmer Press.
In this chapter, expert teachers' knowledge of teaching is discussed in terms of the anthropological and psychological construct of situated knowledge. As an example, the author traces the (partially hypothetical) development of one teacher's knowledge of how to teach a particular math topic to second graders. Four scenarios of teaching and learning subtraction with regrouping, taken across 40 years in this teacher's lifetime, are presented and discussed. [Topics: 6, 13, 16] 1988-019

Leinhardt, G. (1989). Development of an expert explanation: An analysis of a sequence of subtraction lessons. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 67-124). Hillsdale, NJ: Erlbaum. (Also in *Cognition and Instruction*, 1987, 4(4), 225-282)
This chapter traces the teaching and learning that occurred during an 8-day unit on subtraction with regrouping in an expert teacher's second-grade classroom. Detailed analyses of this expert's lessons focused both on the teacher's explanations and on students' knowledge growth (assessed before, during, and after instruction). Content analyses generated models of the teacher's and students' knowledge. A structural analysis of the lessons generated a model of an expert explanation in elementary mathematics. [Topics: 5a, 13, 16] 1989-032

Leinhardt, G. (1989). Math lessons: A contrast of novice and expert competence. *Journal for Research in Mathematics Education*, 20(1), 52-75.
From a study of novice and expert teachers, three important elements needed for constructing expert mathematics lessons are identified and described: rich agendas, consistent but flexible lesson structures, and explanations that meet the goals of clarifying concepts and procedures and having students learn and understand them. The novice-expert contrast highlighted the nature of the competencies expert teachers possessed and suggested some areas of instruction for future teachers. [Topics: 5a, 13, 16] 1989-033

Leinhardt, G. (1990). *Towards understanding instructional explanations* (Tech. Rep. No. CLIP-90-03). Pittsburgh, PA: University of Pittsburgh, LRDC.

This report discusses the nature of instructional explanations as they differ from common, disciplinary, and self explanations. Each type is examined and compared with respect to specific features (problem type, initiation, evidence, form, and audience). Given this context, three examples of instructional explanations are explored, one by a teacher in history, one by a student in history, and one by teachers and students together in mathematics. [Topics: 5a, 5d, 13, 16] 1990-032

Leinhardt, G. (1990). *Weaving instructional explanations in history* (Tech. Rep. No. CLIP-90-02). Pittsburgh, PA: University of Pittsburgh, LRDC.

This report examines the nature of and occasions for instructional explanations in history. Based on theoretical and empirical evidence, the author proposes a typology that consists of two major types of instructional explanations (that and blocked) and four sites or occasions for their use (i.e., to explain metasystems, events, structures, and themes). Examples of classroom use of these kinds of explanations are provided. [Topics: 5d, 6, 13, 16] 1990-033

Leinhardt, G. (1990). A contrast of novice and expert competence in math lessons. In J. Lowyck & C. M. Clark (Eds.), *Teacher thinking and professional action* (pp. 75-97). Leuven, Belgium: Leuven University Press.

Using techniques from ethnography and cognitive psychology, lessons taught by novice and expert elementary math teachers were observed, analyzed, and compared to reveal specific competencies expert teachers possess. The author identifies three important elements in expert teachers' math lessons: rich agendas, consistent but flexible lesson structures, and explanations that meet specific goals. [Topics: 5a, 13, 16] 1990-034

Leinhardt, G. (1990). Capturing craft knowledge in teaching. *Educational Researcher, 19*(2), 18-25.

This exploration raises some problems and poses some solutions in identifying the craft knowledge of teaching. Craft knowledge, or wisdom of practice, is one important component in the design and validation of new national teacher assessments. The prototype assessment exercises for National Board certification are one site in which such craft knowledge has been used. From that experience and others, some guides for inspecting exercises are suggested. [Topics: 3, 13, 16] 1990-035

Leinhardt, G. (1991). Evaluating *The New Handbook of Teacher Evaluation*. *Educational Researcher, 20*(6), 23-25.

Review of J. Millman & L. Darling-Hammond (1990). *The New Handbook of Teacher Evaluation: Assessing Elementary and Secondary School Teachers*. Newbury Park, CA: Sage Publications. [Topics: 3] 1991-031

Leinhardt, G., & Bickel, W. (1989). Instruction's the thing wherein to catch the mind that falls behind. In R. Slavin (Ed.), *School and classroom organization* (pp. 197-246). Hillsdale, NJ: Erlbaum. (Also in *Educational Psychologist*, 1987, 22(2), 177-207)

This chapter explains the social and historical background of separate compensatory and special education programs but argues that separate programs can no longer be justified. The authors review evidence from numerous studies to show that the features of effective instructional strategies are effective across programs and they discuss the implications of effective instruction research for future research, reform policies, and current educational practices. [Topics: 4, 16, 17] 1989-034

Leinhardt, G., & Greeno, J. (1986). The cognitive skill of teaching. *Journal of Educational Psychology, 78*(2), 75-95. (Also in P. Goodyear (Ed.), *Teaching knowledge intelligent tutoring*. Norwood, NJ: Ablex, 1991).

The complex cognitive skill of teaching is described in terms of two fundamental knowledge systems: lesson structure and subject matter. A formal model of the process of instruction in elementary mathematics is presented and examined in light of empirical data from both expert and novice teachers. Instructional segments are carefully analyzed in order to clarify the nature of instructional action and goal systems that support competence in this socially dynamic and complex task domain. [Topics: 13, 16] 1986-051

Leinhardt, G., & Ohlsson, S. (1990). Tutorials on the structure of tutoring from teachers. *Journal of Artificial Intelligence in Education, 2*(1), 21-46.

This article examines how five exemplary elementary math teachers use meta-communication to facilitate the task of the learners in their classrooms. Based on theoretical considerations, the authors hypothesize the five categories of meta-communication. Results of the study generated some principles for the design of good instruction. [Topics: 2, 13, 16] 1990-036

Leinhardt, G., & Putnam, R. T. (1986). Profile of expertise in elementary school mathematics teaching. *Arithmetic Teacher, 34*(4), 28-29.

This article describes three distinct programs of expert-novice research that each revealed important aspects of expertise in teaching. Based on these findings, a profile of expertise in elementary mathematics instruction was developed. Experts have specialized pedagogical

content knowledge; they provide explanations that are cohesive and tightly connected to the representations being used; they have intricate mental agendas for lessons; and they develop and continually refine curriculum scripts for frequently taught topics. [Topics: 13, 16] 1986-020

Leinhardt, G., & Putnam, R. T. (1987). The skill of learning from classroom lessons. *American Educational Research Journal, 24*(4), 557-587.
This article presents a model of the skills a student needs to have to make sense of a mathematics lesson taught by a good teacher. The model of the learner contains a variety of cognitive competencies: an action system, a lesson parser, an information gatherer, a knowledge generator, and an evaluator. A description of how the model functions during a two-day lesson sequence provides an empirical example. [Topics: 2, 13, 16] 1987-026

Leinhardt, G., & Smith, D. (1985). Expertise in mathematics instruction: Subject matter knowledge. *Journal of Educational Psychology, 77*(3), 247-271.
This expert-novice study explores the relationship between teachers' classroom behavior and their subject matter knowledge of a topic, in this case fractions. Among the experts studied, some displayed rich conceptual knowledge of fractions and others relied on precise knowledge of algorithms. Implications of these knowledge differences are discussed. [Topics: 5a, 13, 16] 1985-019

Leinhardt, G., Putnam, R. T., Stein, M. K., & Baxter, J. (1991). Where subject knowledge matters. In J. Brophy (Ed.), *Advances in research on teaching: Teachers' subject matter knowledge and classroom instruction* (Vol. 2, pp. 87-113). Greenwich, CT: JAI Press.
Subject-matter knowledge is one important element in the complex cognitive skill of teaching. Focusing on elementary mathematics instruction, this chapter discusses how the nature of a teacher's subject-matter knowledge influences his or her teaching. Four sites are examined for teachers' use of subject-matter knowledge: agendas, curriculum scripts, explanations, and representations. [Topics: 5a, 13, 16] 1991-032

Leinhardt, G., Weidman, C., & Hammond, K. M. (1987). Introduction and integration of classroom routines by expert teachers. *Curriculum Inquiry, 17*(2), 135-176.
Successful teachers establish, rehearse, and maintain a set of routines (shared, socially scripted behaviors) to reduce the cognitive complexity of the instructional environment and allow instruction to proceed fluidly and efficiently. From extensive observations of 6 experts' classrooms, three types of routines were identified: management, instructional support, and teacher-student exchange. Approximately 85% of the routines introduced in the first four days of school were still in use at midyear. [Topics: 13, 16] 1987-027

Leinhardt, G., Zaslavsky, O., & Stein, M. K. (1990). *Annotated bibliography of selected articles on graphing and functions* (Tech. Rep. No. CLIP-90-01). Pittsburgh, PA: University of Pittsburgh, LRDC.
Brief descriptions of 30 research papers and articles on the teaching or learning of functions, graphs, and graphing are provided. This annotated bibliography was the first stage in a project that led to a major review of research in this area. [Topics: 5a, 10] 1990-037

Leinhardt, G., Zaslavsky, O., & Stein, M. K. (1990). Functions, graphs, and graphing: Tasks, learning, and teaching. *Review of Educational Research, 60*(1), 1-64.
This review of the introductory instructional substance of functions and graphs analyzes research on the tasks associated with functions and some of their representations, as well as analyzing the nature of student learning and various approaches to teaching. This is a review of a specific and significant part of the mathematics curriculum, reflecting the issues raised by recent theoretical research concerning how specific content and content contribute to learning and meaning. [Topics: 1, 5a, 10, 16] 1990-038

Lesgold, A. (1987). Intelligent tutoring systems: Practice opportunities and exploratory models. In J. Barrett & J. Hedberg (Eds.), *Using computers intelligently in tertiary education. Proceedings of the 1987 meeting of the Australian Society for Computers in Learning* (pp. 7-24). Kensington, New South Wales: University of New South Wales.
This chapter presents examples of a focused practice system and an exploratory environment, both implemented using artificial intelligence and graphics interface tools. It describes a troubleshooting tutor that combines these approaches and discusses how the combination affords opportunities for instruction in metacognitive skills. [Topic: 7] 1987-028

Lesgold, A. (1988). The integration of instruction and assessment in technical jobs. *Assessment in the service of learning. Proceedings of the 1987 ETS Invitational Conference* (pp. 81-88). Princeton, NJ: Educational Testing Service.
This article discusses possibilities and research problems for mixing computer-based training with assessment, commenting on a proposal to calibrate

measures from training systems as elements of assessment. Training systems maintain a student model; the Sherlock system maintains both a competence and a performance model. However, knowledge during the course of acquisition is fragile and unreliable, and assessments in different media may differ. Therefore, efforts should be made to couple on-line data collection with paper-and-pencil tests, to build a database relating the measures in the different media. [Topics: 3, 7] 1988-020

Lesgold, A. (1988). Toward a theory of curriculum for use in designing intelligent instructional systems. In H. Mandl & A. Lesgold (Eds.), *Learning issues for intelligent tutoring systems* (pp. 114-137). New York: Springer-Verlag.
This chapter specifies the kinds of knowledge that an intelligent instructional system must have: knowledge of curriculum goals and subgoals, knowledge of the subjects to be taught, and metacognitive knowledge. [Topic: 7] 1988-021

Lesgold, A. (1989). Context-specific requirements for models of expertise. In D. A. Evans & V. L. Patel (Eds.), *Cognitive science in medicine: Biomedical modeling* (pp. 373-403). Cambridge, MA: The MIT Press.
This chapter proposes new methods of modeling medical expertise and of student modeling for computer-assisted medical education. A context-specific abstracted problem space approach, though inelegant, may be more practical than exhaustive modeling of the student's knowledge, and hybrid connectionist models may have advantages for modeling expertise. [Topics: 7, 13] 1989-035

Lesgold, A. (1989). Preserving what we know about educational technology as paradigms change [Review of R. M. Gagne (Ed.), *Instructional technology: Foundations*]. *Contemporary Psychology, 34*(6), 569-570.
Review of R. M. Gagne (Ed.), *Instructional Technology: Foundations*. (1987). Hillsdale, NJ: Erlbaum. [Topic: 7] 1989-036

Lesgold, A. (1990). Tying development of intelligent tutors to research on theories of learning. In H. Mandl, E. De Corte, N. Bennett, & H. F. Friedrich (Eds.), *Learning and instruction: European research in an international context* (Vol. 2.1, pp. 321-337). Oxford: Pergamon Press.
This chapter reviews some forms of intelligent computer systems for learning, and the theory needed to explain and develop successful intelligent tutoring systems. Smithtown, an exploratory microworld, and Sherlock, a coached practice environment, are discussed. Such systems can be viewed as laboratories for testing instructional theories. [Topic: 7] 1990-039

Lesgold, A. (1991). Research methodology in the postinformatic age. *Behavior Research Methods, Instruments, & Computers, 23*(2), 109-111.
The widespread availability of computers and powerful software as commodities should offer new approaches to research methodology. These approaches should take advantage of existing tools and address new research questions that are prompted by the penetration of informatic resources into our society. [Topic: 7] 1991-033

Lesgold, A. & Glaser, R. (Eds.). (1989). *Foundations for a psychology of education*. Hillsdale, NJ: Erlbaum.
This volume brings together leading scholars' reviews of aspects of cognitive psychology that are significant to advances in educational theory and practice. [Topic: 1] 1989-037*

Lesgold, A. M. (1986). Computer resources for learning. *Peabody Journal of Education, 62*(2), 60-74.
This article describes some of the ways in which computers can be important learning resources. Computers can provide immediate feedback, focus the students' attention, and diagnose the individual students' knowledge. They can provide more than drill, e.g., and simulated labs, intelligent tutoring systems, coached games. Detailed knowledge of particular computers should not be a goal of instruction, worthwhile computer literacy develops from good problem solving knowledge and good communication skills. [Topic: 7] 1986-021

Lesgold, A. M. (1986). Critical research issues in the implementation of the next generation of educational technology. *Machine-Mediated Learning, 1*(4), 373-381.
A new approach to intelligent computer-assisted instruction (ICAI) architecture, which depends upon object-oriented program methods and languages, makes the structure of a curriculum explicit by having modules of program code correspond to curriculum goals and subgoals. The flow of control among modules depends on three kinds of knowledge: domain, curriculum, and aptitude or metacognitive. Research is needed to develop supporting pedagogical and programming knowledge. [Topic: 7] 1986-022

Lesgold, A. M. (1986). Intelligent tutoring systems for professionals. In H. Stone (Ed.), *Proceedings of the IEEE Fall Joint Computer Conference, Dallas, TX* (pp. 18-23). Washington, DC: IEEE Computer Society Press.
Tools are becoming available for developing intelligent tutoring systems to teach professional and technical jobs. One basic tool is a method for analyzing jobs that involve considerable problem

solving, such as electronics troubleshooting. A second tool is a combined device simulation and hypertext design capability. Combined with recent developments in cognitive instructional science and artificial intelligence, these tools promise affordable and efficient computer-based tutors that can speed up on-the-job learning. [Topic: 7] 1986-023

Lesgold, A. M. (1986). Preparing children for a computer-rich world. *Educational Leadership*, 43(6), 7-11.
Standard computer software, including word processors and spreadsheets, can help children become better at acquiring knowledge, solving problems, and communicating ideas. Computers should be used as assistants to facilitate and extend learning and problem solving. [Topic: 7] 1986-024

Lesgold, A. M. (1987). *General report of the International Conference on Information Technologies and Basic Learning, Paris, October 1986*. Paris: Organisation for Economic Co-operation and Development.
A report to the Organization for Economic Cooperation and Development. Provides guidance for planning technology for education, pedagogical and technological contexts and implications for policy. [Topic: 7] 1987-029

Lesgold, A. M. (1987). Education applications. In S. C. Shapiro (Ed.), *Encyclopedia of artificial intelligence* (pp. 267-272). New York: Wiley & Sons.
Defines, describes, and exemplifies intelligent computer-based instruction. [Topic: 7] 1987-030

Lesgold, A. M. (1987). Information technologies and basic learning: Main issues and future prospects. Part one of information technologies and basic learning: Reading, writing, science and mathematics. In A. M. Lesgold (Ed.), *General report of the International Conference on Information Technologies and Basic Learning, Paris, October 1986* (pp. 13-49). Paris: Organisation for Economic Co-operation and Development.
A report to OECD. Provides guidance for planning technology for education, pedagogical and technological contexts and implications for policy. [Topic: 7] 1987-031

Lesgold, A. M. (1987). Research to improve science and math teaching [Review of *Mathematics, Science and Technology Education: A Research Agenda*]. *Contemporary Psychology*, 32(10), 874-875.
This article is a review of *Mathematics, Science and Technology Education: A Research Agenda*. Report by the National Research Council: Commission on Behavioral and Social Sciences and Education, Committee on Research in Mathematics, Science and Technology Education. 1985. Washington, DC: National Academy Press. [Topics: 5a, 16] 1987-032

Lesgold, A. M. (1988). Medical decision making: Formal or intuitive? [Review of S. Schwartz and T. Griffin, *Medical thinking: The psychology of medical judgment and decision making*]. *Contemporary Psychology*, 33(9), 781-782.
Review of S. Schwartz and T. Griffin, *Medical Thinking: The Psychology of Medical Judgment and Decision Making*. (1986). New York: Springer-Verlag. [Topic: 13] 1988-022

Lesgold, A. M. (1988). Problem solving. In R. J. Sternberg & E. E. Smith (Eds.), *The psychology of human thought* (pp. 188-213). Cambridge, MA: Cambridge University Press.
This chapter provides a review of cognitive theories of aspects of problem solving: problem spaces, methods, production systems, types of knowledge, expertise, acquisition of expertise, metacognition, and creativity. [Topic: 6] 1988-023

Lesgold, A. M., Gabrys, G., & Magone, M. (1990). *Cognitive and instructional theories of impasses in learning*. Pittsburgh, PA: University of Pittsburgh, LRDC.
This report describes a series of experiments designed to study impasses in learning. Impasses were produced, but patterns of impasse phenomena were not reproduced reliably enough to support or disconfirm a theory of impasses in learning. [Topic: 10] 1990-040

Lesgold, A. M., Glaser, R., Lajoie, S., Eastman, R., Eggan, G., Greenberg, L., Logan, D., Magone, M., Weiner, A., Wolf, R. & Yengo, L. (1985). *Guide to cognitive task analysis*. Pittsburgh, PA: University of Pittsburgh, LRDC.
Cognitive task analysis is a new approach to characterizing problem-solving jobs and the skills necessary to perform them. It builds a characterization of expert performance in a job and of developing competence. This guide sets forth the methods used to diagnose Air Force specialists' competence and the development of their skill in electronics troubleshooting. [Topic: 18] 1985-020

Lesgold, A. M., Lajoie, S. P., Bunzo, M., & Eggan, G. (1988). *SHERLOCK: A coached practice environment for an electronics troubleshooting job*. Pittsburgh, PA: University of Pittsburgh, LRDC.
This report describes SHERLOCK, a computer-based coached practice environment for Air Force trainees learning a complex troubleshooting job, and discusses the design approach. [Topics: 7, 18] 1988-024

Lesgold, A., & Hammond, K. L. (1985). Do we look for independence or near decomposability [Commentary on an article by Humphreys &

Evett]. *The Behavioral and Brain Sciences, 8*, 716-717.
Lexical recognition may take place via processes that are nearly decomposable, that is, where interactions within a subsystem are stronger than interactions between subsystems. Looking at lexical recognition this way can have clinical and pedagogical uses. [Topics: 5c, 12] 1985-021

Lesgold, A., Bonar, J. G., & Ivill, J. (1989). Toward intelligent systems for testing. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 337-360). Hillsdale, NJ: Erlbaum.
Steering testing in a computer-based intelligent tutoring system, diagnostic testing used often in small amounts, might enable individualization of the testing process to make it more efficient in steering instruction. [Topics: 3, 7] 1989-038

Lesgold, A., Chipman, S., Brown, J. S., & Soloway, E. (1990). Intelligent training systems. *Annual Review of Computer Science, 4*, 383-394.
This article calls for a program to develop computer-based training that runs seamlessly from core cognitive science research through demonstration efforts through development of prototypes. Research needs include clarifying how understanding relates to performance, developing techniques for capturing complex cooperative work and decision making, developing formal connectionist-symbolic models of expert job knowledge, developing formal policy generators for instruction, and developing methods for assessment. [Topics: 7, 18] 1990-041

Lesgold, A., Katz, S., Bunzo, M., Eggan, G., & Hughes, E. (1990). *Curriculum content and design specifications for Sherlock II*. Pittsburgh, PA: University of Pittsburgh, LRDC.
This report describes the instructional design and approach to be taken in implementing Sherlock II, the improved version of the automatic troubleshooting tutor for the F-15 manual avionics test station. The basic approach to be taken is to build from the successes of Sherlock I, adding more conceptual support and more complete system simulations, using video graphics instead of computer graphics whenever possible, and moving from the fragile environment of the Xerox AI Environment to standard hardware and software. [Topics: 7, 18] 1990-042

Lesgold, A., Lajoie, S., Eastman, R., Eggan, G., Gitomer, D., Glaser, R., Greenberg, L., Logan, D., Magone, M., Weiner, A., Wolf, R., & Yengo, L. (1986). *Cognitive task analysis to enhance technical skills training and assessment*. Pittsburgh, PA: University of Pittsburgh, LRDC.
This report contains the results of an extensive program of cognitive task analysis studies of Air Force jet engine mechanics and avionics technicians. The methods for diagnosing critical knowledge necessary for good performance of cognitively demanding tasks are described. Practice in cognitively difficult tasks, to include emphasis on strategy, planning, and self-monitoring, is prescribed. [Topic: 18] 1986-025

Lesgold, A., Lajoie, S., Logan, D., & Eggan, G. (1990). Applying cognitive task analysis and research methods to assessment. In N. Frederiksen, R. Glaser, A.M. Lesgold, & M. Shafto (Eds.), *Diagnostic monitoring of skill and knowledge acquisition* (pp. 325-350). Hillsdale, NJ: Erlbaum.
This chapter considers the possibilities for using cognitive psychological approaches to improve different forms of testing. The authors discuss their preliminary efforts to do diagnostic testing in the course of instruction of troubleshooting skill, informed by cognitive analysis rather than by statistical correlations. The concept of an effective problem space makes it tractable to represent expert and novice behavior computationally. [Topic: 3] 1990-043

Lesgold, A., Resnick, L. B., & Hammond, K. (1985). Learning to read: A longitudinal study of word skill development in two curricula. In G. E. MacKinnon & T. G. Waller (Eds.), *Reading research: Advances in theory and practice* (Vol. 4, pp. 107-138). New York: Academic Press.
This chapter describes a 5-year longitudinal study of the development of reading skill, particularly of the relationship between automatic word recognition and comprehension. Efficient word recognition early in the study was correlated with superior reading comprehension later. The study suggests that efficient, automatic word recognition should be a goal of early reading instruction. [Topic: 5c] 1985-022

Lesgold, A., Rubinson, H., Feltovich, P., Glaser, R., Klopfer, D., & Wang, Y. (1988). Expertise in a complex skill: Diagnosing x-ray pictures. In M. T. H. Chi, R. Glaser, & M. Farr (Eds.), *The nature of expertise* (pp. 311-342). Hillsdale, NJ: Erlbaum.
This chapter compares highly expert radiologists' diagnoses of x-ray pictures to those of radiology residents. In contrast to the residents, the experts immediately (perceptually) reach the stage where a general schema is in control. Such schemas have sets of processes that enable them to reach and confirm a diagnosis. Also, the residents are less able to accommodate new information to schemas it may not match perfectly. [Topic: 13] 1988-025

Lesgold, S. B., Peled, I., & Resnick, L. B. (1989). *Using semantic computer models for learning about number systems and word problems.* Pittsburgh, PA: University of Pittsburgh, LRDC.
This report is a description of TRAINWORLD, a computer system of representing numbers by trains of different lengths and arithmetic operators by machines that operate on those trains. The different types of machines for adding and subtracting correspond to the semantic categories for addition and subtraction word problems: combine, change, and compare. Results of trials with first graders, working both individually and in pairs, are presented. Children were classified into three levels of competence based on their work with the trains and machines, and the levels are described. [Topics: 5a, 7] 1989-039

Levin, E. K., Zigmond, N., & Birch, J. W. (1985). A follow-up study of 52 learning disabled adolescents. *Journal of Learning Disabilities, 18*(1), 2-7.
The study reported in this article was designed to document, four years later, the progress of 52 learning disabled adolescents who entered a special education program in the ninth grade. The sample were typical LD adolescents: old for their grade placement, with severe reading retardation and moderate math retardation. Results indicated impressive gains for all students although approximately half of the achievement growth had taken place in the first year of the LD program. [Topic: 17] 1985-023

Levine, J. M. (1985). Bringing order out of chaos [Review of *Groups: Interaction and performance*]. *Contemporary Psychology, 30*(2), 102-104.
This article provides a critical review of J. E. McGrath's *Groups: Interaction and Performance* (1984). Englewood Cliffs, NJ: Prentice-Hall. [Topic: 8] 1985-024

Levine, J. M. (1989). Reaction to opinion deviance in small groups. In P. B. Paulus (Ed.), *Psychology of group influence* (2nd ed., pp. 187-231). Hillsdale, NJ: Erlbaum.
This chapter presents a critical review of recent theoretical and empirical work on reaction to opinion deviance in small groups. [Topic: 8] 1989-040

Levine, J. M., & McBurney, D. H. (1986). The role of olfaction in social perception and behavior. In C. P. Herman, M. P. Zanna, & E. T. Higgins (Eds.), *Physical appearance, stigma, and social behavior: The Ontario Symposium* (Vol. 3, pp. 179-217). Hillsdale, NJ: Erlbaum.
This chapter reviews research from several disciplines regarding the role of odor in human social perception and behavior. Particular effort is made to relate this work to social psychological theory. [Topic: 8] 1986-026

Levine, J. M., & Moreland, R. L. (1985). Innovation and socialisation in small groups. In S. Moscovici, G. Mugny, & E. Van Avermaet (Eds.), *Perspectives on minority influence* (pp. 143-169). Cambridge: Cambridge University Press.
This chapter applies Moreland and Levine's (1982) model of group socialization to the domain of innovation and minority influence. [Topic: 8] 1985-025

Levine, J. M., & Moreland, R. L. (1986). Outcome comparisons in group contexts: Consequences for the self and others. In R. Schwarzer (Ed.), *Self-related cognitions in anxiety and motivation* (pp. 285-303). Hillsdale, NJ: Erlbaum.
This chapter extends Levine and Moreland's (1987) analysis of outcome comparisons in group contexts by emphasizing the affective, cognitive, and behavioral consequences of such comparisons. [Topic: 8] 1986-027

Levine, J. M., & Moreland, R. L. (1987). Social comparison and outcome evaluation in group contexts. In J. C. Masters & W. P. Smith (Eds.), *Social comparison, social justice, and relative deprivation: Theoretical, empirical, and policy perspectives* (pp. 105-127). Hillsdale, NJ: Erlbaum.
This chapter presents a model of the process by which individuals evaluate their outcomes in group contexts. [Topic: 8] 1987-033

Levine, J. M., & Moreland, R. L. (1989). Social values and multiple outcome comparisons. In N. Eisenberg, J. Reykowski, & E. Staub (Eds.), *Social and moral values: Individual and societal perspectives* (pp. 195-210). Hillsdale, NJ: Erlbaum.
This chapter extends Levine and Moreland's (1987) analysis of outcome comparisons in group contexts by emphasizing multiple, as opposed to single, comparisons. [Topic: 8] 1989-041

Levine, J. M., & Moreland, R. L. (1990). Progress in small group research. *Annual Review of Psychology, 41*, 585-634.
This article critically reviews research done in the last decade dealing with small group processes. [Topic: 8] 1990-044

Levine, J. M., & Moreland, R. L. (1991). Culture and socialization in work groups. In L. Resnick, J. Levine, & S. Teasley (Eds.), *Perspectives on socially shared cognition* (pp. 257-279). Washington, DC: American Psychological Association.
This chapter discusses the content of work group culture and the socialization practices that are used to instill this culture in new members. [Topic: 8] 1991-034

Levine, J. M., & Russo, E. M. (1987). Majority and minority influence. In C. Hendrick (Ed.), *Review*

of personality and social psychology: Group processes (Vol. 8, pp. 13-54). Newbury Park, CA: Sage.
This chapter presents a critical review of recent theoretical and empirical work on majority and minority influence. [Topic: 8] 1987-034

Loftus, E. F., Banaji, M., Schooler, J. W., & Foster, R. A. (1987). Who remembers what? Gender differences in memory. *Michigan Quarterly Review, 26*, 64-85.
Individual differences between men and women in memory are considered. It is concluded that neither gender possesses superior memory, per se. Rather, men and women differ in the types of information that they best remember. [Topic: 9] 1987-035

Loftus, E. F., Donders, K., Hoffman, H. G., & Schooler, J. W. (1989). Creating new memories that are quickly accessed and confidently held. *Memory and Cognition, 17*(5), 607-616.
This article describes a study which examined subjects reaction times for recognizing objects for which they have received misleading postevent information. The results indicated that misinformation does introduce some form of interference not detected by a simple test of accuracy. [Topic: 9] 1989-042

Loftus, E. F., Korf, N. L., & Schooler, J. W. (1989). Misguided memories: Sincere distortions of reality. In J. Yuille (Ed.), *Credibility assessment: A theoretical and research perspective* (pp. 155-174). Boston: Kluwer.
Considerable research has demonstrated that people can produce sincere but inaccurate recollections by unwittingly assimilating the misleading suggestions of others. Additional research has investigated ways to distinguish real from suggested memories. Typically, people have great difficulty determining whether or not a memory is real. A recent exploratory study examined a new potential technique for discriminating real from suggested memories: negative feedback. The authors explored the hypothesis that subjects would be less reluctant to believe they were incorrect when recalling a suggested memory compared to a real memory. [Topic: 9] 1989-043

Loftus, E. F., Schooler, J. W., Boone, S., & Kline, D. (1987). Time went by so slowly: Overestimation of event duration by males and females. *Applied Cognitive Psychology, 1*, 3-13.
This article describes three experiments in which 469 subjects watched a short videotape of a bank robbery and later estimated the duration of the tape. Subjects invariably overestimated the duration. A more stressful version of the event produced greater overestimates than a less stressful version. The relationship between induced arousal and time estimation appears to be different for men and women. [Topic: 9] 1987-036

Mandl, H., & Lesgold, A. (Eds.). (1988). *Learning issues for intelligent tutoring systems*. New York: Springer-Verlag.
This volume contains articles addressing concerns of learning for designers of computer-based tutoring systems. [Topic: 7] 1988-026*

Martin, D. T., & Bickel, W. E. (1988). The educational experiences of ethnic and American students in the Pittsburgh Public Schools, 1911-1928. *Midwestern History of Education Quarterly, 16*, 149-166.
Using data drawn from public school and social service agency files, this article compares and contrasts the experiences of immigrant, black, and Caucasian American students in the Pittsburgh Public Schools early in the century. [Topic: 14] 1988-027

McCutchen, D., Bell, L. C., France, I. M., & Perfetti, C. A. (1991). Phoneme-specific interference in reading: The visual tongue-twister effect revisited. *Reading Research Quarterly, 26*, 87-103.
This article reports studies showing that the tongue-twister effect, in which readers take longer to read tests that repeat initial consonants (as in Peter Piper picked), is due to specific phonological interence. When subjects had to remember short strings of digits while reading tongue-twisters, the phonetic content of the digit names interacted with the phonetic content of the tongue twisters. The authors conclude that comprehension processes use phonological codes and that these codes are subject to interference. [Topic: 12] 1991-035

McKeown, M. G. (1985). The acquisition of word meaning from context by children of high and low ability. *Reading Research Quarterly, 20*(4), 482-496.
This study investigated the ability of fifth grade students to derive word meaning from context. The findings demonstrate characteristics of processing that differentiate successful and less successful meaning acquisition and underscore the complexity of the meaning acquisition process. [Topics: 10, 12, 16] 1985-026

McKeown, M. G. (1991). Learning word meanings from definitions: Problems and potential. In P. Schwanenflugel (Ed.), *The psychology of word meanings* (pp. 137-156). Hillsdale, NJ: Erlbaum.
This chapter includes an analysis of the problems that dictionary definitions present for young learners in trying to understand the meanings of new words, lays out principles for more effective definitions, and demonstrates the effectiveness of

such definitions for student learning. [Topics: 10, 12] 1991-036

McKeown, M. G., & Beck, I. L. (1988). Learning vocabulary: Different ways for different goals. *Remedial and Special Education*, 9(1), 42-46.
This article discusses the features of effective vocabulary instruction. The design of a vocabulary program for intermediate grades is then presented. The emphasis is that the nature of the activities should depend on the goal of instruction, the nature of the words taught, and the characteristics of the learners. [Topics: 10, 12, 16] 1988-028

McKeown, M. G., & Beck, I. L. (1990). The assessment and characterization of young learners' knowledge of a topic in history. *American Educational Research Journal*, 27(4), 688-726.
This article focuses on the background knowledge that young learners bring to their study of history by characterizing students' knowledge of events leading to the Revolutionary War just before and a year after they study the topic in school. Results of interviews with students suggest that their knowledge is characterized by simple associations and a lack of connected structures. [Topics: 2, 5d, 16] 1990-045

McKeown, M. G., & Curtis, M. E. (Eds.). (1987). *The nature of vocabulary acquisition*. Hillsdale, NJ: Erlbaum.
This book contains chapters on vocabulary learning and instruction. [Topic: 10, 12, 16] 1987-037*

McKeown, M. G., Beck, I. L., Omanson, R. C., & Pople, M. T. (1985). Some effects of the nature and frequency of vocabulary instruction on the knowledge and use of words. *Reading Research Quarterly*, 20(5), 522-535.
This article reports the study of two types of vocabulary instruction, one requiring only associations between words and definitions, the other presenting elaborated word meanings and diverse contexts. Frequency of encounters with words was also varied. Rich instruction showed an advantage for comprehension of stories and interpretation of contexts containing the taught words. [Topics: 10, 12, 16] 1985-027

McQuaide, J., Fienberg, J., & Leinhardt, G. (1991). *Transcript of George Polya's film Let Us Teach Guessing* (Tech. Rep. No. CLIP-91-01). Pittsburgh, PA: University of Pittsburgh, LRDC.
This report consists of a transcript of George Polya's film Let Us Teach Guessing. It includes drawings of all of the visual elements in the lesson and thus provides in print format a valuable tool for analyzing the presentation of mathematical concepts by this eminent teacher. It was prepared for use in an ongoing research project which has as its theme the relationship between teaching and learning in particular subject-matter areas. [Topics: 5a, 13] 1991-037

McSpadden, M. D., Schooler, J. W., & Loftus, E. F. (1988). Here today, gone tomorrow: The appearance and disappearance of context effects. In G. M. Davies & D. M. Thomson (Eds.), *Memory in context: Context in memory* (pp. 215-229). Sussex, England: Wiley & Sons.
Evidence is reviewed examining whether guided memory techniques can improve recollections when subjects have previously received misleading information. Three studies suggested that guided memory could sometimes facilitate retrieval in the face of misleading information but the effects were rather fragile and unpredictable. [Topic: 9] 1988-029

Means, M. L., & Voss, J. F. (1985). Star Wars: A developmental study of expert and novice knowledge structures. *Journal of Memory and Language*, 24, 746-757.
Using the domain of the movie Star Wars, this article examines differences in the knowledge structures of experts and novices within each of six grade levels. A probe procedure determined whether a subject could successfully identify a basic action and its related goals within a hierarchical structure. It was concluded that age-related representational differences were due primarily to the differential prior knowledge of schema. Expert-novice differences were attributed to differential ability to utilize thematic and major goal knowledge to interpret actions for older individuals, and to experts' ability to interpret specific story actions for younger individuals. [Topic: 2] 1985-028

Medin, D. L. & Wattenmaker, W. D. (1987). Category cohesiveness, theories, and cognitive archeology. In U. Neisser (Ed.), *Categories reconsidered: The ecological and intellectual bases of categories* (pp. 25-62). Cambridge, MA: Cambridge University Press.
The authors argue that a similarity-based approach to conceptual coherence is insufficient to explain the richness of conceptual structure, and opt instead for a knowledge-based approach to conceptual coherence. A knowledge-based approach emphasizes that coherence derives from both the internal causal structure of a conceptual domain and the position of the concept in the complete knowledge base. [Topics: 6, 9, 10] 1987-038

Medin, D. L., Wattenmaker, W. D., & Hampson, S. E. (1987). Family resemblance, conceptual

cohesiveness, and category construction. *Cognitive Psychology, 19*, 242-279.
Many people have argued that natural categories are organized in terms of a family resemblance principle. This article reports seven experiments using a sorting task to evaluate the conditions under which people prefer to construct categories according to a family resemblance principle. In the first set of experiments, across a variety of stimulus materials, instructions, procedures, and category structures, family resemblance sorting was almost never observed. The second set of studies explored the idea that interproperty relationships rather than independent features serve to organize categories. The authors found that people will abandon unidimensional sorting in favor of sorting by correlated properties, especially when they can be causally connected. [Topics: 9, 10] 1987-039

Miller, S. E., Leinhardt, G., & Zigmond, N. (1988). Influencing engagement through accommodation: An ethnographic study of at-risk students. *American Educational Research Journal, 25*(4), 465-487.
This article reports a study which used ethnographic methodology to explore the academic world of regular and learning disabled students in one high school. In response to perceived student needs, various accommodations were made by this school to enhance students' academic engagement and limit potential dropping out behavior. These accommodation processes resulted both in modified demands on students and in support for students to meet those demands. [Topics: 14, 16, 17] 1988-030

Miller, S. E., Leinhardt, G., & Zigmond, N. (1991). Accommodating at-risk pupils. *SET: Research Information for Teachers, 1*, 1-4.
This article briefly summarizes the findings of a study that used ethnographic methodology to explore the academic world of regular and learning disabled students in one high school. In response to perceived student needs, various accommodations were made by this school to enhance students' academic engagement and limit potential dropping out behavior. These accommodation processes resulted both in modified demands on students and in support for students to meet those demands. [Topics: 4, 14, 16] 1991-038

Mitchell, A. A., & Chi, M. T. H. (1986). Measuring knowledge within a domain. In P. Nagy (Ed.), *The representation of cognitive structures* (pp. 89-121). Toronto: Ontario Institute for Studies in Education.
An important concern in education is the measurement of students' knowledge within a domain. Recently, student knowledge has also become an important psychological variable. Within the information-processing paradigm, it is thought to be one of the most important variables which affects behavior. Little effort, however, has been directed at actually measuring differences in the content and organization of information within a domain between individuals with high and low levels of knowledge. This is largely due to the fact that developing procedures and measures of the content and structure of knowledge must necessarily be based on a theory of memory. In this chapter, the authors discuss models of memory and procedures based on these models for measuring knowledge. [Topics: 1, 2, 9] 1986-028

Moore, J. D. (1991). Evaluating natural language generation facilities in intelligent systems. In J. Neal & S. Walter (Eds.), *Proceedings of the Workshop on Evaluation of Natural Language Processing Systems* (pp. 133-139). Rome, NY: Rome Air Development Center.
This article describes some of the special problems of attempting to evaluate the natural language components of intelligent systems and describes a proposed evaluation study. [Topic: 12] 1991-039

Moore, J. D., & Paris, C. L. (1991). The EES explanation facility: Its tasks and its architecture. *Proceedings of the AAAI workshop on Comparitive Analysis of Explanation Planning Architectures* (pp. 65-79). Annaheim, CA: AAAI Press.
This article describes the goals of an expert system explanation facility and represents a system architecture that achieves these goals. It also compares this architecture to several other text general architectures in terms of the goals. [Topic: 12] 1991-040

Moore, J. D., & Paris, C. L. (1991). Requirements for an expert system explanation facility. *Computational Intelligence, 7*(4).
For the past several years, the authors have worked on building an explanation component for an expert system building framework (or 'shell'), the Explainable Expert System (EES) Framework. In this article, the authors describe the characteristics believed to be essential for an explanation component of an expert system. Important features of the EES architecture that support the desired capabilities are identified. Some areas where fruitful work remains to be done are also discussed. [Topic: 12] 1991-084

Moore, J. D., & Swartout, W. R. (1990). A reactive approach to explanation: Taking the user's feedback into account. In C. L. Paris, W. R.

Swartout, & W. C. Mann (Eds.), *Natural language generation in artificial intelligence and computational linguistics* (pp. 3-48). Norwell, MA: Kluwer.
This chapter describes an architecture for explanation that treats explanation as an interactive process and which supports a dialogue between advice-giver and advice-seeker. It describes an implemented system that can elaborate or clarify previous explanations and answer follow-up questions in the context of the ongoing dialogue. [Topic: 12] 1990-046

Moore, J. D., & Swartout, W. R. (1990). Pointing: A way toward explanation dialogue. *Proceedings of the Eighth National Conference on Artificial Intelligence* (pp. 457-464). Menlo Park, CA: AAAI Press/The MIT Press.
The authors describe a hypertext-like interface that allows users to ask questions about previous system-generated explanations by pointing to the portion of the explanation they would like clarified. The feasibility of such an interface rests on the system's ability to understand what the user is pointing at, i.e., its own explanations. A planning approach to explanation generation is described, which records the design process that produced an explanation so that it can be used in later reasoning. The authors show how synergy arises from combining a pointing-style interface with a text planning generation system, making explanation dialogues more feasible. [Topics: 7, 12] 1990-047

Moreland, R. L., & Levine, J. M. (1988). Group dynamics over time: Development and socialization in small groups. In J. E. McGrath (Ed.), *The social psychology of time: New perspectives* (pp. 151-181). Newbury Park, CA: Sage.
This chapter reviews prior work on group development and group socialization and discusses how these processes affect one another. [Topic: 8] 1988-031

Moreland, R. L., & Levine, J. M. (1989). Newcomers and oldtimers in small groups. In P. B. Paulus (Ed.), *Psychology of group influence* (2nd ed., pp. 143-186). Hillsdale, NJ: Erlbaum.
This chapter extends Moreland and Levine's (1982) analysis of group socialization by elaborating their discussion of the assimilation of new members into a group and the accommodation of the group to its new members. [Topic: 8] 1989-044

Moreland, R. L., & Levine, J. M. (1991). Problem identification by groups. In S. Worchel, W. Wood, & J. Simpson (Eds.), *Productivity and process in groups* (pp. 257-279). Newbury Park, CA: Sage.
This chapter reviews theoretical and empirical work on problem identification by small groups. [Topic: 8] 1991-041

Mukhopadhyay, S., Resnick, L. B., & Schauble, L. (1990). Social sense-making in mathematics: Children's ideas of negative numbers. In G. Booker, J. Cobb, & T. N. de Mendicuti (Eds.), *Proceedings of the Fourteenth Psychology in Mathematics Education Conference* (Vol. 3, pp. 281-288). Mexico City, Mexico: International Group for the Psychology of Mathematics Education.
This article reports on a narrative story-telling methodology that was used to tap children's use of a debts-and-assets model to support calculations with negative numbers. Children showed superior performance on problems posed in the context of the story, in contrast to their ability to solve isomorphic problems presented as formal equations. Performance was most enhanced for underschooled children from India, who were very familiar with the social situations and problems depicted. The debts-and-assets analogue appeared to encourage the use of a Dividend Number Line model, resulting in difficulties when children had to perform calculations involving crossing over the zero amount from a debts to an assets status. [Topic: 5a] 1990-048

Nelson-Le Gall, S. (1985). Help-seeking behavior in learning. In E. W. Gordon (Ed.), *Review of research in education* (Vol. 12, pp. 55-90). Washington, DC: American Educational Research Association.
This chapter provides an examination of social-cognitive, motivational, and situational factors influencing children's effectiveness in using other children as learning resources. First a brief, critical overview of extent theories of help-seeking behavior is presented. The bases for the reconceptualization of help seeking as a general learning and problem-solving strategy that can be identified in the developmental psychological literature are highlighted in this presentation. This overview is presented as background to an integrative review of empirical studies of children's active use of others in learning situations which then follows. [Topics: 14, 16] 1985-029

Nelson-Le Gall, S. (1990). Academic achievement orientation and help-seeking behavior in early adolescent girls. *Journal of Early Adolescence, 10*(2), 176-190.
This article reports on a study which evaluated task persistence and help-seeking behaviors among 40 girls. The girls were classified as high or low in mastery orientation using their scores on

a subset of items on the Intellectual Achievement Responsibility Scale. Task persistence and help-seeking behaviors were observed while the girls performed a perceptual/performance cognitive task. Results indicated that task persistence measured as time spent working on the task did not vary with grade level or mastery orientation. As predicted, girls high in mastery orientation displayed proportionately more adaptive bids for help that focused on solving the task than did their low mastery counterparts. Moreover, girls high in mastery orientation viewed help seeking more favorably as an alternative means of goal attainment than did low mastery-oriented girls. The results are discussed in terms of individual differences in strategies for coping with stress in achievement settings. [Topic: 14] 1990-049

Nelson-Le Gall, S. A. (1985). Motive-outcome matching and outcome foreseeability: Effects on attribution of intentionality and moral judgments. *Developmental Psychology, 21*(2), 332-337.

The influence of motive-outcome valence matching and outcome foreseeability (foreseeable or unforeseeable) on the perception of intentionality and moral judgments were examined. Children and adult subjects were asked directly to make attributions of intentionality to story characters and to make a moral judgment of the character. Positive and negative intended effects were distinguished from unintended ones by the adults as well as by the children. Also, children's moral judgments were differentiated by the level of foreseeability of the effected outcome. Differences between the judgments of children and adults are discussed, as are implications of the findings for research on the development of social causality concepts. [Topic: 6] 1985-030

Nelson-Le Gall, S. A. (1987). Necessary and unnecessary help-seeking in children. *Journal of Genetic Psychology, 148*(1), 53-62.

This article reports on a study which examined the task-related help-seeking behavior of 85 third- and fifth-grade boys and girls of varying ability. Children were given the opportunity to seek help as they desired. Their bids for help were classified objectively as necessary or unnecessary. Their preference for indirect versus direct help was also assessed. Results indicated that, with increased age, children seek more necessary help than unnecessary help and clearly prefer indirect help to direct help. Girls, more than boys, were found to prefer mastery-oriented help, especially at low ability levels. Implications of the findings for understanding individual differences in the adaptive use of help-seeking in achievement situations are discussed. [Topics: 2, 14] 1987-040

Nelson-Le Gall, S., & DeCooke, P. A. (1987). Same-sex and cross-sex help exchanges in the classroom. *Journal of Educational Psychology, 79*(1), 67-71.

This article reports on a study which combined interviews and naturalistic observations of the same children to examine same-sex and cross-sex help exchanges in reading and math classes among third- and fifth-grade boys and girls. Overall, girls were perceived by their classmates to be more academically competent and more likable as helpers than were boys. Nevertheless, girls were not the targets of cross-sex help seeking more than boys were. Both boys and girls sought help more frequently from same-sex than from opposite-sex classmates. When help seeking occurred between opposite-sex classmates, girls were more likely than boys to report liking these helpers as much as their same-sex helpers. The implications of these findings for children's learning and peer status are discussed. [Topics: 14, 16] 1987-041

Nelson-Le Gall, S., & Glor-Scheib, S. (1985). Help seeking in elementary classrooms: An observational study. *Contemporary Educational Psychology, 10*, 58-71.

This article reports on a study which explores how elementary school children employ help seeking as a means of problem solving in the classroom. In-depth naturalistic observations were made of high-, average-, and low-ability students in reading and math classes at the first-, third-, and fifth-grade levels. Overall, children's rates of help seeking were higher in math than in reading. Boys and girls did not differ overall in the amount of help sought. Boys and girls did differ, however, in the type of help they requested. Children of different ability levels were found to vary not only in rate of help seeking and type of help requested, but also in the type of responses elicited from their helper choices. Implications of these findings for children's achievement, learning, and social adjustment in the classroom are discussed. [Topics: 14, 16] 1985-031

Nelson-Le Gall, S., & Glor-Scheib, S. (1986). Academic help-seeking and peer relations in school. *Contemporary Educational Psychology, 11*, 187-193.

This article describes a study which investigated the relationship between peer relations and help-seeking behaviors. The subjects were 26 third grade and 48 fifth grade boys and girls. The roster-rating technique was used to obtain measures of children's perceived academic

competence and social attractiveness in their reading and math classes. Intensive naturalistic observation of a subset of these children in their classrooms provided data on actual help-seeking behavior. The relationship between peer status and academic help-seeking was found to vary with the target of the help-seeking overture and the type of help requested. [Topics: 14, 16] 1986-029

Nelson-Le Gall, S., & Jones, E. (1990). Cognitive-motivational influences on the task-related help-seeking behavior of black children. *Child Development, 61*, 581-589.

The described study examined the relationship between mastery motivation, self-assessment of performance, and task-related help-seeking behavior in third-grade and fifth-grade African American children. Neither children's self-assessments of performance nor their overall rate of help seeking varied with level of measured mastery motivation. However, when they perceived task failure to be otherwise inevitable, children characterized by a high mastery orientation preferred help that allowed them to figure out solutions for themselves as opposed to help that supplied a ready-made solution; children low in measured mastery motivation showed no such preference. [Topics: 2, 6, 14] 1990-050

Nelson-Le Gall, S., & Scott-Jones, D. (1985). Teachers' and young children's perceptions of appropriate work strategies. *Child Study Journal, 15*(1), 29-42.

Two studies were conducted to examine teachers' and young children's perceptions of the appropriateness of various work strategies. In Study 1, teachers responded to interview questions about the appropriateness of persistence without help in relation to help-seeking and other strategies children use to accomplish difficult tasks. Study 2 examined preschool, kindergarten, and first-grade children's beliefs about this issue. Findings indicated that there was some disagreement between teachers and children about the relative appropriateness of seeking help from others versus persisting without help as a response to task difficulty. The implications of the findings for achievement motivation research and classroom practices are discussed. [Topics: 14, 16] 1985-032

Nelson-Le Gall, S., DeCooke, P., & Jones, E. (1989). Children's self-perceptions of competence and help seeking. *Journal of Genetic Psychology, 150*(4), 457-459.

This article reports on a study which examined third- and fifth-grade children's perceptions of their cognitive competence and task-related help seeking. The results support a conceptualization of help seeking as an adaptive achievement behavior. The lower children's perceptions of their competence, the more help they sought. Children also requested more necessary than unnecessary help. In general, children preferred indirect help to direct help, but this pattern of preference was stronger among fifth-grade than among third-grade children. [Topics: 2, 14] 1989-045

Nelson-Le Gall, S., Kratzer, L., Jones, E., & DeCooke, P. (1990). Children's self-assessment of performance and task-related help seeking. *Journal of Experimental Child Psychology, 49*, 245-263.

In the reported experiments, third- and fifth-grade children blocked into low and high verbal skill groups performed a multi-trial verbal task. Children's self-assessment of performance was found to influence both the frequency and type of help sought with the task. High levels of task-related skill was associated with the discriminating use of help seeking as an achievement strategy, especially among boys and older children. Findings are discussed in terms of grade and sex differences in the use of internally based cues for performance evaluation. [Topics: 2, 14] 1990-051

Nersessian, N. J., & Resnick, L. B. (1989). Comparing historical and intuitive explanations of motion: Does naive physics have a structure? *Proceedings of the Eleventh Annual Conference of the Cognitive Science Society* (pp. 412-417). Hillsdale, NJ: Erlbaum.

Are students' explanations of motion generated by an underlying structure? This article addresses that question by exploring striking parallels between intuitive explanations and those offered by medieval scholastics. Using the historical record, it is possible to reconstruct an inferential structure that generates medieval explanations. The authors posit a parallel structure for intuitive explanations. [Topic: 5b] 1989-046

Odoroff, E., & Leinhardt, G. (1990). *Writing tales with details* (Tech. Rep. No. CLIP-90-05). Pittsburgh, PA: University of Pittsburgh, LRDC.

A study of an exceptional writing teacher showed how one teacher moved students beyond the recognition of desired features in examples of good short-story writing to the generation of those features in their own writing. Analysis of videotaped lessons helped produce a model that shows how this teacher carefully constrains writing processes so that they lead to acceptable stories. [Topics: 5c, 13, 16] 1990-052

Ohlsson, S. (1985). Retrieval processes in restructuring: Answer to Keane. *Scandinavian Journal of Psychology, 26*, 366-368.

In a comment on the attempt by Ohlsson (1984) to interpret the Gestalt theory of restructuring and insight in information processing terms, Keane argues that memory retrieval is central to restructuring and that Ohlsson ignores higher-order memory organizations. Careful comparison between Ohlsson's and Keane's hypotheses about what kind of retrieval occurs in restructuring reveals that they take different stands on three well-known issues in the study of knowledge representation: semantic vs. episodic memory, declarative vs. procedural knowledge, and small vs. large memory units. Since humans obviously have several types of memory units, both types of retrieval processes may be involved in restructuring. [Topic: 6] 1985-033

Ohlsson, S. (1986). Rational versus empirical learning. In H. J. Kugler (Ed.), *Information Processing 86. Proceedings of the IFIP 10th World Congress* (p. 841). North Holland: Elsevier Science Publishers.

Empirical learning is defined as the induction of new knowledge from past experience. Rational learning, on the other hand, consists of the derivation of new knowledge from previously learned knowledge. Current theories of procedural learning are typically theories of empirical learning. It is argued that psychological theories of learning should contain both an empirical and a rational component. [Topics: 6, 9] 1986-030

Ohlsson, S. (1986). Some principles of intelligent tutoring. *Instructional Science, 14*, 293-326.

Research on intelligent tutoring systems is discussed from the point of view of providing moment-by-moment adaptation of both content and form of instruction to the changing cognitive needs of the individual learner. The implications of this goal for cognitive diagnosis, subject-matter analysis, teaching tactics, and teaching strategies are analyzed. The results of the analyses are stated in the form of principles about intelligent tutoring. A major conclusion is that a computer tutor, in order to provide adaptive instruction, must have a strategy which translates its tutorial goals into teaching actions, and that, as a consequence, research on teaching strategies is central to the construction of intelligent tutoring systems. [Topic: 1] 1986-031

Ohlsson, S. (1987). Sense and reference in the design of interactive illustrations for rational numbers. In R. Lawler & M. Yazdani (Eds.), *Artificial intelligence and education: Learning environments and tutoring systems* (Vol. 1, pp. 307-344). Norwood, NJ: Ablex.

It is a common tactic in the teaching of arithmetic to provide the learner with pictures and embodiments of various kinds. However, the pedagogy of illustrations is not well understood. Analysis of the concept of meaning in relation to arithmetic shows that full understanding of arithmetic implies intellectual possession of a number of different intellectual constructions, among them a teleological, an analytical, and a referential semantics for arithmetic. It is argued that the primary purpose of illustrations for elementary arithmetic is to clarify the semantics of the language of arithmetic. An informal analytical semantics for rational number concepts is presented. Construction of a referential semantics for the concept of ratio leads to the conjecture that illustrations for the rational numbers are necessarily incomplete in the sense that they can, in principle, only illustrate some aspects of rational numbers. The results of these analyses are summarized in a prescriptive theory. [Topics: 2, 5a, 9] 1987-043

Ohlsson, S. (1987). Transfer of training in procedural learning: A matter of conjectures and refutations? In L. Bolc (Ed.), *Computational models of learning* (pp. 55-88). New York: Springer-Verlag.

An analysis of transfer of training with respect to problem solving heuristics results in two transfer mechanisms, one based on the interplay between conjectures and refutations, and one based on the partitioning of a goal into independently realizable parts of subgoals. First, rules called proposers produce suggestions about which operator(s) should be considered in the current situation, while other rules--called censors--refute those suggestions which previous experience has shown to be bad. Second, subgoaling rules encode knowledge of which parts of a goal description can be attained separately. Subgoaling rules learned while solving one task can facilitate the solution to another task, if the tasks share at least one subgoal. A computer program is written on the basis of this theory, and shown to be able to transfer within a simple task domain. [Topics: 6, 7] 1987-044

Ohlsson, S. (1987). Truth versus appropriateness: Relating declarative to procedural knowledge. In D. Klahr, P. Langley, & R. Neches (Eds.), *Production system models of learning and development* (pp. 287-327). Cambridge, MA: MIT Press.

It is argued that current models of learning focus on empirical learning, i.e., the induction of new cognitive procedures from experience. However, previous knowledge plays an important role in human learning. A formal model of knowledge-based learning is described and

implemented on a running computer simulation model. The model explains data from a simple verbal reasoning task. The drop in reaction time on this is mainly due to the substitution of perceptual processes for cognitive operations, according to the model. Relations to other models of procedural learning are discussed. [Topic: 6, 9] 1987-045

Ohlsson, S. (1988). *The conceptual basis of subtraction with regrouping: A mathematical analysis* (Tech. Rep. No. KUL-88-02). Pittsburgh, PA: University of Pittsburgh, LRDC.

The purpose of this report is to identify a knowledge base, list of concepts and principles, and to derive the standard subtraction algorithm from it. Such a derivation requires a theory of the place value notation, which is also developed in this report. The result of the enterprise consists of (a) the concepts and principles presupposed in the derivation, and (b) the concepts and principles constructed on the way to the description of the subtraction algorithm. Some difficulties with partial or approximate explanations are discussed, and the hypothesis advanced that conceptual knowledge is not generative in the sense envisioned by mathematics educators. [Topics: 2, 5a] 1988-032

Ohlsson, S. (1988). Computer simulation and its impact on educational research and practice. *International Journal of Educational Research, 12*(1), 5-34.

The use of computer simulation as a technique for building formal models of mental processes forces the cognitive psychologist to consider the content of knowledge, in particular strategic or heuristic knowledge. The rationale and work mode of imulation research are summarized. A short review illustrates the range of phenomena with educational relevance to which the simulation technique has been applied. Computer simulation and education are predicted to interact in several ways in the future, most directly through computerized teaching tools like intelligent tutoring systems and systems for automatic cognitive diagnosis. [Topics: 1, 7] 1988-033

Ohlsson, S. (1988). Mathematical meaning and applicational meaning in the semantics of fractions and related concepts. In J. Hiebert & M. Behr (Eds.), *Number concepts and operations in the middle grades* (Vol. 2, pp. 53-92). Hillsdale, NJ/Reston, VA: Erlbaum/NCTM.

The meanings of fraction and several related concepts (quotient, ratio, rate, proportion, etc.) are analyzed. It is argued that such concepts have a hybrid semantic structure, mixing mathematical and empirical strands of meaning. The meaning of fraction depends partly on the mathematical theory of rational numbers and partly on how fractions are used to describe physical quantities. Detailed analyses in support of this hypothesis are presented for a variety of fraction concepts. [Topics: 2, 5a] 1988-034

Ohlsson, S. (1990). Cognitive science and instruction: Why the revolution is not here (yet). In H. Mandl, E. DeCorte, N. Bennett, & H. F. Friedrich (Eds.), *Learning and instruction. European research in an international context: Social and cognitive aspects of learning and instruction* (Vol. 2.1, pp. 561-600). Oxford: Pergamon Press.

Although advances in instructional technology have been made, they fall short of expectations. The author argues that our current theory of cognition cannot, in principle, support a revolution in the design of instruction. The current theory explains how an agent orchestrates a set of primitive capabilities to attain some goal in a given situation. However, schools aim to teach concepts and principles, rather than skills. The problematic part of instruction--the part for which a theory-based revolution is most urgently needed--is the promotion of conceptual understanding. Before the design of instruction can be based on cognitive theory, a need exists to augment the current theory with hypotheses about the form, function, and origin of conceptual, as opposed to procedural, knowledge. [Topic: 1] 1990-053

Ohlsson, S. (1990). The mechanism of restructuring in geometry. *Proceedings of the Twelfth Annual Conference of the Cognitive Science Society* (pp. 237-244). Cambridge, MA: Massachusetts Institute of Technology.

Restructuring consists of a change in the representation of the current search state, a process which breaks an impasse during problem solving by opening up new search paths. A corpus of 52 think-aloud protocols from the domain of geometry was scanned for evidence of restructuring. The data suggest that restructuring is accomplished by re-parsing the geometric diagram. [Topic: 6] 1990-054

Ohlsson, S. (1990). Trace analysis and spatial reasoning: An example of cognitive diagnosis and its implications for testing. In N. Frederiksen, R. Glaser, A. Lesgold, & M. G. Shafto (Eds.), *Diagnostic monitoring of skill and knowledge acquisition* (pp. 251-296). Hillsdale, NJ: Erlbaum.

Trace analysis is defined as the analysis of a temporally dense record of behavior, with the purpose of identifying the mental processes that generated the behavior. The theory of problem solving proposed by Allen Nemell and Herbert A.

Simon, here called Enaction Theory, constitutes the theoretical rationale for trace analysis. An example of trace analysis applied to a think-aloud protocol from a spatial reasoning task is presented in detail. The relation between trace analysis and psychometric methods is discussed, and a speculative proposal for theory referenced test construction put forward. [Topics: 3, 6] 1990-055

Ohlsson, S. (1991). Memory for problem solving steps. *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society* (pp. 370-375). Hillsdale, NJ: Erlbaum.
The underlying assumption that people store information about problem solving steps in memory was tested by measuring subjects' memory of their own problem solving steps in four different ways. The results support the assumption that people store enough information in memory to enable induction of new problem solving rules. [Topic: 9] 1991-085

Ohlsson, S. (1991). *Young adults' understanding of evolutionary explanations: Preliminary observations.* Pittsburgh, PA: University of Pittsburgh, LRDC.
To appreciate the intellectual power of scientific theories, students must construct their own scientific explanations rather than consume the explanations of others. Biological evolution is an advantageous subject matter in which to study students' explanatory reasoning because evolutionary explanations do not require either mathematics or special-purpose notations. Cognitive objectives for introductory instruction in evolution are proposed in this report. The performance of 20 students on theory recall, reading comprehension, and three explanation tasks shows that the students were very far from reaching those objectives. Most students appear to be neither Darwinians, Lamarckians, nor Christian fundamentalists, but to regard evolution as a primitive teological process for which no explanation is needed and which happens when the organism needs to change in order to survive. When students do focus on the mechanism of evolution, they locate the source of change in genetic or mental processes. [Topics: 5b, 9, 16] 1991-042

Ohlsson, S. (1991). Knowledge requirements for teaching: The case of fractions. In P. Goodyear (Ed.), *Teaching knowledge and intelligent tutoring* (pp. 25-59). Norwood, NJ: Ablex.
Three different views of teaching are discussed: teaching as the communication of subject matter, teaching as the remediation of mental representations, and teaching as the facilitation of knowledge construction. Current learning theories focus on the acquisition of procedural knowledge, but the core content of most instructional topics consists of concepts and principles. The design of intelligent tutoring systems that teach conceptual knowledge requires research in learning theory, rather than research in system building, per se. [Topics: 5a, 7] 1991-043

Ohlsson, S. (1991). System hacking meets learning theory: Reflections on the goals and standards of research in artificial intelligence and education. *Journal of Artificial Intelligence in Education*, 2(3), 5-18.
This article discusses the status of current learning theory and the relationship between this goal and current AI & Ed research. It is shown that solutions to the supposedly technical problems involved in implementing instructional systems depend on assumptions about learning. The goal of contributing to learning theory has implications for good research practice as well and the author believes that AI and Ed will cease to be separate disciplines and become a branch of Cognitive Psychology. [Topic: 7] 1991-044

Ohlsson, S., & Bee, N. (1991). Intra-individual differences in fractions arithmetic. In F. Furinghetti (Ed.), *Proceedings of the Fifteenth Conference of the International Group for the Psychology of Mathematics Education* (Vol. 3, pp. 121-128). Assisi, Italy: International Group for the Psychology of Mathematics Education.
Recent evidence indicates that strategy variability in arithmetic is not limited to inter-individual differences and to changes over time. Every student has a space of different strategies for each task, and he/she decides anew which strategy to use on each problem. Furthermore, the frequency distributions of strategy spaces are highly skewed, with few frequent strategies and many infrequent ones. Current theories of procedural learning fail to explain these regularities. [Topics: 5a, 9] 1991-045

Ohlsson, S., & Bee, N. (1991). Radical strategy variability: A challenge to models of procedural learning. In L. Birnbaum (Ed.), *Proceedings of the International Conference of the Learning Sciences* (pp. 351-356). Charlottesville, VA: American Association for Computers in Education.
Current theories of procedural learning typically assume that a learner has a single strategy for each cognitive task. This single strategy assumption is contradicted by data which show that each learner entertains a space of strategies for the task he or she is trying to master. Proposed are three quantitative regularities of strategy spaces. [Topics: 5a, 9] 1991-086

Ohlsson, S., & Hall, N. (1990). *The cognitive function of embodiments in mathematics instruction* (Tech.

Rep. No. KUL-90-02). Pittsburgh, PA: University of Pittsburgh, LRDC.

Educators frequently recommend a teaching scenario for arithmetic in which an arithmetic procedure is first explained in terms of an embodiment, then introduced with respect to an expanded procedure or some other pedagogical notation. Finally, the expanded procedure is transformed into the target procedure. The authors explain the workings of this teaching scenario in terms of three learning mechanisms: proceduralization, analogical procedure construction, and simplification. The authors present a theory predicting a major determinant of the pedagogical effectiveness of this teaching scenario. [Topic: 5a] 1990-056

Ohlsson, S., & Langley, P. (1988). Psychological evaluation of path hypotheses in cognitive diagnosis. In H. Mandl & A. Lesgold (Eds.), *Learning issues for intelligent tutoring systems* (pp. 42-62). New York: Springer-Verlag.

An Artificial Intelligence technique for identifying students' errors in mathematics is proposed. The technique consists of backward reasoning from an observed, incorrect answer, to a hypothesis about the sequence of verbal operations which produced that answer. The technique is applied to errors in subtraction and is shown to be able to identify several well-known subtraction errors, as well as identify one new error type not previously described. The main advantage of the technique is that it does not rely on a pre-defined catalogue of error patterns. [Topics: 3, 7] 1988-035

Ohlsson, S., & Rees, E. (1991). Adaptive search through constraint violations. *Journal of Experimental and Theoretical Artificial Intelligence, 3*, 33-42.

The authors describe HS, a production system that learns to control knowledge through adaptive search. HS encodes general domain knowledge in state constraints, patterns that describe those search states that are consistent with the principles of the problem domain. When HS encounters a search state that violates a state constraint, it revises the production rule that generated that state. The appropriate revisions are computed by regressing the constraint through the action of the production rule. HS can learn to solve problems that it cannot solve without learning. The authors present a Blocks World example of a rule revision, empirical results from both initial learning experiments and transfer experiments in the domain of counting, and an informal analysis of the conditions under which this learning technique is likely to be useful. [Topics: 7, 9] 1991-046

Ohlsson, S., & Rees, E. (1991). The function of conceptual understanding in the learning of arithmetic procedures. *Cognition and Instruction, 8*(2), 103-179.

The authors propose a theory of conceptual understanding and its role in the learning and execution of arithmetic procedures. Their hypothesis is that conceptual understanding constrains problem states and, thereby, enables the learner to monitor his or her own performance and to detect and correct his or her errors. They have implemented their theory in the Heuristic Searcher (HS), a computer model that learns arithmetic procedures. Their theory provides a new interpretation of the role of conceptual understanding in arithmetic learning, generates testable predictions about human behavior, deals successfully with theoretical issues that cause difficulties for other theories of learning, and fares well on evaluation criteria such as generality and parsimony. [Topics: 5a, 7, 9] 1991-047

Ohlsson, S., Bee, N. V., & Zeller, P. A. (1989). *Empirical evaluation of a computer-based learning environment for fractions* (Tech. Rep. No. KUL-89-07). Pittsburgh, PA: University of Pittsburgh, LRDC.

This report presents a field test of two computer-based illustrations for fractions. Seven academically weak students who received traditional, procedure oriented classroom instruction in fractions participated in a sequence of one-on-one tutoring sessions in which they solved problems and exercises in a computer-based learning environment called the Fraction Tutor. Comparisons between pretest and posttest performance show an increase in performance, but the increase is too small to be pedagogically significant. Analysis of the students' solution strategies does not support the hypothesis that the concrete illustrations helped these students understand fractions. The implications of this finding for further research into computer-based learning environments for arithmetic are discussed. [Topics: 5a, 7] 1989-047

Ohlsson, S., Nickolas, S. E., & Bee, N. V. (1987). *Interactive illustrations for fractions: A progress report* (Tech. Rep. No. KUL-87-03). Pittsburgh, PA: University of Pittsburgh, LRDC.

The purpose of this progress report is to summarize the status of the Fractions Tutor, an intelligent tutoring system that is designed to teach children conceptual understanding of fractional quantities with the help of interactive illustrations (so-called microworlds). The report summarizes the pedagogical rationale that underlies the design of the system, shows screen

snapshots of the different illustrations, presents an overview of the formative evaluations carried out to date, and ends with a discussion of the authors' plans for supplying the tutor with intelligent tutoring strategies. [Topics: 5a, 7] 1987-046

Oliver, W. L., & Schneider, W. (1988). Using rules and task division to augment connectionist learning. *Proceedings of the Tenth Annual Conference of the Cognitive Science Society* (pp. 55-61). Hillsdale, NJ: Erlbaum.

Learning as a function of task complexity was examined in human learning and two connectionist simulations. An example task involved learning to map basic input/output digital logic functions for six digital gates (AND OR, XOR and negated versions) with 2- or 6-inputs. Humans given instruction learned the task in about 300 trials and showed no effect on the number of inputs. Back propagation learning in a network with 20 hidden units required 68,000 trials and scaled poorly, requiring 5 times as many trials to learn the 6-input gates as to learn the 2-input gates. A second simulation combined backpropagation with task division based upon rules humans use to perform the task. The combined approach improved the scaling of the problem, learning in 3,100 trials and requiring about 3 times as many trials to learn the 6-input gates as to learn the 2-input gates. Issues regarding scaling and augmenting connectionist learning with rule-based instruction are discussed. [Topic: 19] 1988-036

Pavelchak, M. A., Moreland, R. L., & Levine, J. M. (1986). Effects of prior group memberships on subsequent reconnaissance activities. *Journal of Personality and Social Psychology, 50*(1), 56-66.

This article reports research investigating how college students' prior group memberships affected their subsequent efforts to join new groups. [Topic: 8] 1986-032

Peled, I., & Resnick, L. B. (1987). Building semantic computer models for teaching number systems and word problems. In J. C. Bergeron, N. Herscovics, & C. Kieran (Eds.), *Proceedings of the 11th Annual Conference of the Psychology of Mathematics Education* (Vol. 2, pp. 184-190). Montreal: International Group for the Psychology of Mathematics Education.

This article presents issues concerning the construction of models for teaching mathematical concepts and problem solving. As an example of this decision-making process, the authors suggest a computer-based model for teaching natural numbers. This model, which represents natural numbers as well as the operations of addition and subtraction, is aimed at facilitating the solution of word problems. The chapter shows how research on children's informal knowledge of numbers and algorithms, together with research on how children solve word problems, is taken into account. [Topics: 5a, 7, 16] 1987-047

Perfetti, C. A. (1985). *Reading ability*. New York: Oxford Press.

This book is concerned with the general question of how can differences in reading ability be explained? The role of phonology and lexical processes in reading are examined. Comprehension and speech processes in skilled reading are covered. Individual differences in reading and the relationship between verbal efficiency and reading, and finally, reading instruction are discussed. [Topic: 12] 1985-034*

Perfetti, C. A. (1986). Cognitive and linguistic components of reading ability. In B. Foorman & A. Siegel (Eds.), *Learning to read: Cognitive universals and cultural constraints* (pp. 11-40). Hillsdale, NJ: Erlbaum.

Whether there are cognitive universals in learning to read will doubtless prove a difficult question. However, a search for generalizations about reading processes may suggest some constraints on the form of such universals or at least may suggest what kinds of processes are candidates for universals. There are two general questions to pose: (1) What is the nature of ability differences in reading? and (2) How does a child become a skilled reader? Within each of these questions, specific possibilities concerning the role of linguistic and cognitive components will be raised. The author draws on both his own research and on the advances provided in general by cognitive science. Although each conclusion will be based predominately on work with English-speaking populations, the author offers all conclusions in the belief that they may, with appropriate qualification, be general. [Topic: 12] 1986-033

Perfetti, C. A. (1986). Continuities in reading acquisition, reading skill, and reading disability. *Remedial And Special Education (RASE), 7*(1), 11-21.

Reading instruction and remediation are best grounded when based on observation of the continuities among various problems in reading. The problems of reading acquisition, reading skill, and reading disability are linked by their shared connection to word decoding. Learning to read depends on eventual (but not initial) mastery of coding procedures, and even skilled reading depends on coding processes that are low in cost to processing resources. Reading disability may also be understood as representing a point on an ability continuum that contains a wide range of coding ability. Instructional goals of word

reading skill, including rapid and fluent word recognition, follow from these considerations. [Topics: 5c, 17] 1986-034

Perfetti, C. A. (1986). Reading acquisition and beyond: Decoding includes cognition. In N. L. Stein (Ed.), *Literacy in American schools: learning to read and write* (pp. 40-60). Chicago, IL: The University of Chicago Press.

The definition of literacy is a tricky business, but it is important for the study of the development of reading skill. This chapter discusses the importance of decoding in reading acquisition and beyond. There is good evidence to conclude that decoding is important to the development of reading skill. However, what this means in detail is an interesting question, and this is where the definition issue comes in. So, although the author's primary concern lies with the development of reading skill, he begins with some issues concerning the definition of literacy that affect how the development of reading skill is viewed. [Topic: 5c] 1986-035

Perfetti, C. A. (1987). Language, speech, and print: Some asymmetries in the acquisition of literacy. In R. Horowitz & S. J. Samuels (Eds.), *Comprehending oral and written language* (pp. 355-369). New York: Academic Press.

This chapter addresses four general points about the relationship between speech and print: 1) The similarity between speech and print is essentially asymmetrical in some important ways; 2) The asymmetry in similarity between speech and print changes as a child's reading ability improves; 3) For the child who has succeeded at decoding, the commonalities between speech and print are more important than the differences; and 4) For those who have acquired vast reading experience, speech processes become more like reading in some conditions. [Topic: 12] 1987-048

Perfetti, C. A. (1988). Verbal efficiency in reading ability. In G. E. MacKinnon, T. G. Waller, & M. Daneman (Eds.), *Reading research: Advances in theory and practice* (Vol. 6, pp. 109-143). New York: Academic Press.

This chapter summarizes the central features of a theory of reading ability. The theory, the verbal efficiency theory, postulates several component processes in reading comprehension and assumes that individual differences can arise in any of these components. The theory assumes, however, that these processes vary in their potential for efficiency and automaticity, and it is these processes, especially word identification, that are most responsible for differences in reading ability. Research in support of the theory is reviewed and instructional implications are discussed. [Topic: 12] 1988-037

Perfetti, C. A. (1989). The cooperative language processors: Semantic influences in an autonomous syntax. In D. A. Balota, G. B. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension processes in reading* (pp. 205-230). Hillsdale, NJ: Erlbaum.

A main goal of this chapter is to raise the possibility of a parser that is determined (i.e., makes a commitment at each choice point) only for high level constituents and local attachments triggered by syntactic features. In the absence of such features, the parser is less determined to make the full range of intermediate attachments between low level and high level constituents. [Topic: 12] 1989-048

Perfetti, C. A. (1989). There are generalized abilities and one of them is reading. In L. B. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 307-335). Hillsdale, NJ: Erlbaum.

Reading is a restricted domain-general human ability. A restricted ability arises from constraints on the underlying mental process. The generality of an ability is its application across different domains making use of the same restricted processes. [Topic: 12] 1989-049

Perfetti, C. A. (1991). On the value of simple ideas in reading instruction. In S. Brady & D. Shankweiler (Eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 211-218). Hillsdale, NJ: Erlbaum.

The notion that reading is a matter of decoding words and comprehension has been argued. This simple view of reading is examined in this chapter. The alphabetic principle, its role in reading, and the difference between language and reading are also briefly discussed. [Topics: 5c, 12] 1991-048

Perfetti, C. A. (1991). Representations and awareness in the acquisition of reading competence. In L. Rieben & C. Perfetti (Eds.), *Learning to read: Basic research and its implications* (pp. 33-44). Hillsdale, NJ: Erlbaum.

This chapter is a general theoretical account of how a child acquires competence in reading, with special attention given to the role of phonemic knowledge. There are two types of phonemic knowledge. One type, phonemic awareness, develops in mutual support of reading acquisition. [Topics: 5c, 12] 1991-049

Perfetti, C. A. (1991). The psychology, pedagogy, and politics of reading [Feature review of M. J. Adams' *Beginning to read: Learning and thinking about print*]. *Psychological Science*, 2(2), 70-76.

This article is a discussion-review of Marilyn Jager Adams' book on reading, *Beginning to Read: Learning and Thinking About Print*. Cambridge, MA: The MIT Press. The book focuses on what research says and how it has been ignored. [Topic: 5c] 1991-050

Perfetti, C. A., & Bell, L. (1991). Phonemic activation during the first 40 ms of word identification: Evidence from backward masking and priming. *Journal of Memory and Language, 30*, 473-485.
This article reports evidence suggesting that the phonological codes of a word are activated during the first few ms of word reading. Experiments on backward masking, in which subjects report a briefly presented word masked by a nonword, and priming, in which subjects report a briefly presented masked word that follows a nonword prime, support the same conclusion: Prior to complete identification of a word, both the letters and phonemes of a word are activated. [Topic: 12] 1991-051

Perfetti, C. A., & Curtis, M. E. (1986). Reading. In R. F. Dillon & R. J. Sternberg (Eds.), *Cognition and instruction* (pp. 13-57). New York: Academic Press.
Reading as a curriculum is on two levels. The first is reading as the object of instruction and so reading acquisition is addressed. The second is reading as a means of instruction so the processes of skilled reading comprehension are examined. [Topics: 5c, 12] 1986-036

Perfetti, C. A., & McCutchen, D. (1987). Schooled language competence: Linguistic abilities in reading and writing. In S. Rosenberg (Ed.), *Advances in applied psycholinguistics, reading, writing, and language learning* (Vol. 2, pp. 105-141). New York: Cambridge University Press.
In this chapter, the authors propose that there are general principles of language competence that, with schooling, come to support reading and writing. Schooled language competence is a restricted set of linguistic abilities that are partly distinct from general cognitive skills. Reading especially depends on the reflexive operation of these abilities. Writing, while sharing a dependence on basic language abilities, requires the development of a much more controlled, nonreflexive cognitive ability that interacts with language processes. [Topic: 12] 1987-049

Perfetti, C. A., & Zhang, S. (1991). Phonological processes in reading Chinese characters. *Journal of Experimental Psychology: Learning, Memory and Cognition, 17*, 633-643.
This article reports on a series of character reading experiments with native speakers of Chinese which addressed the role of phonological processes. The experiments used brief exposures of characters, presented under conditions of backward masking and priming. Taken together, the results of the experiments confirm the assumption that the identification of a Chinese character is not mediated by phonological information. However, the identification process appears to immediately produce the pronunciation of the character name. Thus, while Chinese differs from alphabetic writing systems in its potential for pre-lexical activation, its phonological information is very quickly activated in reading. [Topic: 12] 1991-052

Perfetti, C. A., Beck, I., Bell, L. C., & Hughes, C. (1987). Phonemic knowledge and learning to read are reciprocal: A longitudinal study of first grade children. *Merrill-Palmer Quarterly, 33*(3), 283-319.
An important question is the relationship between phonological awareness and learning how to read. The authors report a longitudinal study of first grade readers that examined this relationship by using tasks of phonological awareness that differ in their demands on analytic processes as opposed to synthetic processes. They found that phonemic deletion, a task that requires analysis, has a reciprocal relation with first-grade progress in learning to read. Phoneme blending, a task that requires synthesis rather than analysis, has a simpler causal relationship with reading progress. The general conclusion is that phonological awareness is both a cause and an effect of progress in reading. [Topic: 12] 1987-050

Perfetti, C. A., Bell, L. C., & Delaney, S. M. (1988). Automatic (prelexical) phonetic activation in silent word reading: Evidence from backward masking. *Journal of Memory and Language, 27*, 59-70.
This article presents evidence favoring the assumption that identifying a word includes very early activation of the word's phonemes. When subjects identify a briefly exposed word such as made, their identification is better if the word is masked by a nonword that is homophonic to it (e.g. MAYD) than one that has the same letter overlap without homophony (e.g. MARD). Such a result implies that even prior to identification, the word's phonemes are activated. [Topic: 12] 1988-038

Perfetti, C. A., Beverly, S., Bell, L., Rodgers, K., & Faux, R. (1987). Comprehending newspaper headlines. *Journal of Memory and Language, 26*, 692-713.
This article reports a series of experiments on how people understand newspaper headlines, which are notorious for omitting articles, prepositions, and conjunctions. The authors contrast a syntactic hypothesis with a problem solving hypothesis for

how readers try to understand the ambiguities that result. The results favor the syntactic hypothesis, and support the more general idea that comprehension of linguistic inputs is initially controlled by automatic syntactic procedures. [Topic: 12] 1987-051

Pierce, J., & Cooley, W. W. (1985). A communication network for educational researchers. *Educational Researcher, 14*(1), 14-17.

Some computer networks permit educational researchers to use microcomputers, terminals, or communicating word processors for communication with colleagues. Networking is defined, several examples are given, and the Educational Research Forum on CompuServe is used to illustrate the possibilities. The organization and structure of the Forum are discussed. Advantages and costs of computer networking are explained, and potential uses for AERA are highlighted. [Topic: 4] 1985-035

Putnam, R. T., Lesgold, S. B., Resnick, L. B., & Sterrett, S. G. (1987). Understanding sign change transformations. In J. C. Bergeron, N. Herscovics, & C. Kieran (Eds.), *Proceedings of the 11th International Conference on the Psychology of Mathematics Education* (Vol. 1, pp. 338-344). Montreal: International Group for the Psychology of Mathematics Education.

The study reported here examined students' understanding of sign-change rules in elementary algebra, focusing on their informal, intuitive understanding of quantities in situations and their ability to link this understanding to formal mathematical expressions. The authors believe that increasing students' understanding of the referential meaning of algebra's formal symbol system may facilitate the learning of formal rules and the application of algebra to problem solving and learning more advanced mathematics. The ultimate goal of this research is to develop ways to improve students' understanding of the symbolic manipulations they learn in algebra. [Topic: 5a] 1987-052

Putnam, R. T., deBettencourt, L. U., & Leinhardt, G. (1990). Understanding of derived fact strategies in addition and subtraction. *Cognition and Instruction, 7*(3), 245-285.

This article reports on a study which examined children's justifications and evaluations of derived-fact strategies--strategies for solving addition and subtraction problems by using known combinations--to explore their knowledge of underlying part-whole relationships. Both LD and normal students' explanations of the derived-fact strategies for addition were examined. Students' explanations were used to develop a partial model of the knowledge underlying the derived-fact strategies. [Topics: 5a, 10] 1990-057

Rabinowitz, M., & Chi, M. T. H. (1986). An interactive model of strategic processing. In S. J. Ceci (Ed.), *Handbook of the cognitive, social, and neuropsychological aspects of learning disabilities* (pp. 83-102). Hillsdale, NJ: Erlbaum.

This chapter asserts that learning disabled children perform poorly because of deficiencies in strategic processing which derive from the relationship between existing knowledge in semantic memory and the use of cognitive strategies. Specifically, the authors argue that both the decision to use a strategy and the efficiency with which a strategy can be used are based on a complex interaction with the conceptual knowledge to which the strategy is to be applied. The influence of this knowledge on processing is illustrated with the aid of a computer simulated environment in which a spreading activation memory system is modelled. [Topics: 2, 6, 17] 1986-037

Rabinowitz, M., & Glaser, R. (1985). Cognitive structure and process in highly competent performance. In F. D. Horowitz & M. O'Brien (Eds.), *The gifted and talented: A developmental perspective* (pp. 75-98). Washington, DC: American Psychological Association.

What allows people to perform in highly competent ways? In contrast to attributing such performance to general intelligence, recent approaches characterize intelligence and aptitude in terms of competent processes. The research reviewed here compares skilled and novice performances in terms of such components and gives particular attention to the role of knowledge. [Topic: 13] 1985-036

Rabinowitz, M., Gobbo, C., & Glaser, R. (1985). *Individual differences in integrating information for problem solving*. Pittsburgh, PA: University of Pittsburgh, LRDC.

Problem solving in educational settings often requires reading information on unfamiliar topics and determining which issues are important or relevant to problem solution. This report presents a study of such unstructured problem solving, in which individual differences in students' strategies were examined. The results show significant individual differences in identifying relevant and irrelevant concepts. [Topic: 6] 1985-037

Rabinowitz, M., Lesgold, A., & Berardi, B. (1988). Modeling task performance: Rule-based and connectionist alternatives. *International Journal of Educational Research, 12*, 35-48.

This article presents two different computer simulations of a problem solving task--the missionaries and cannibals problem. The two

simulations are representative of two different theoretical perspectives--one is based on a production system architecture the second is based on a connectionist architecture. The purpose of the discussion is to present the types of information that must be made explicit in each of the architectures and the consequent variations in the perspective one has of the task. [Topic: 6] 1988-039

Raghavan, K., & Katz, A. (1989). Smithtown: An intelligent tutoring system. *Technological Horizons in Education Journal, 17*(1), 50-53.
This article describes Smithtown, one of a family of new instructional aids known as intelligent tutoring systems (ITSs). It employs artificial-intelligence methods to assist students in beginning-economics courses to improve their problem-solving skills. [Topic: 7] 1989-050

Raghavan, K., Schauble, L., & Glaser, R. (1991). A graphic notation to support reflection in scientific reasoning. In L. Birnbaum (Ed.), *Proceedings of the 1991 International Conference on the Learning Sciences* (pp. 370-374). Charlottesville, VA: Association for the Advancement of Computers in Education.
Previous research on students' scientific reasoning in the context of computer-based laboratories indicates the relationship between goal-driven, plan-oriented activity and success at discovering the laws and regularities. Students who learn the most are skillful at coordinating the complex set of subgoals that comprise experimentation. Students who fail to learn typically fail to reflect upon the inferential meaning of their experimentation activity. To support users in this reflective evaluation, the authors have developed a graphic Discovery and Reflection Notation (DARN) that depicts student activity with the laboratory from three perspectives: the Student View, the Plan View, and the Expert View. Each of the views organizes that student's activities in a different way. [Topics: 6, 7, 9] 1991-053

Regian, J. W., & Schneider, W. (1990). Assessment procedures for predicting and optimizing skill acquisition after extensive practice. In N. Frederiksen, R. Glaser, A. Lesgold, & M. Shafto (Eds.), *Diagnostic monitoring of skill and knowledge acquisition* (pp. 297-323). Hillsdale, NJ: Erlbaum.
Issues relating to personnel assessment for high performance skills are discussed. Two pitfalls in assessment are described. The first is the mapping between predictor measures and prediction criteria. Predictions based on factor based, information processing and cognitive components are described. The second relates to the plasticity of skills, particularly for tasks requiring extended practice. As automatic processing is acquired, factor loading alters greatly. The authors suggest assessing automatic and controlled abilities. Procedures for hierarchial (hurdle) testing are described. Guidelines and an example in air traffic control are provided. [Topic: 19] 1990-058

Reimann, P., & Chi, M. T. H. (1989). Human expertise. In K. J. Gilhooly (Ed.), *Human and machine problem solving* (pp. 161-191). New York: Plenum.
This chapter discusses and interprets results from studies which show that differences between experts' and novices' problem-solving behavior cannot be attributed to better memory or superior domain-independent cognitive strategies, but rather postulates that experts build problem representations that add information to the problem statement in such a way that search for a solution is improved. Specifically, experts elaborate upon the problem formulation by drawing on their huge domain-specific knowledge base. [Topics: 2, 6] 1989-051

Reimann, P., Raghavan, K., & Glaser, R. (1988). *REFRACT, a discovery environment for geometrical optics.* Pittsburgh, PA: University of Pittsburgh, LRDC.
A computer-based laboratory environment called REFRACT provides a discovery environment for learning about refraction. The theoretical framework of inductive learning involved in REFRACT provides the basis for building cognitive simulation models of learning in the domain. [Topic: 5b] 1988-040

Reinet, M., Chi, M. T. H., & Resnick, L. B. (1988). Naive materialistic belief: An underlying epistemological commitment. *Proceedings of the Tenth Annual Conference of the Cognitive Science Society* (pp. 544-551). Hillsdale, NJ: Erlbaum.
A considerable amount of research has focused on students' naive beliefs about electricity, energy, heat, and light. These studies show, in general, that many misconceptions can be traced to students' prescientific beliefs about the world. In this article, the authors explore a basic prescientific commitment--a naive materialistic belief--held by students as well as adults that can account for many of the naive conceptions reported in the literature. An examination of students' explanation of light, heat, electrical circuits, energy, and force suggests that they conceive of these entities in terms of the properties and behavior of real material. Thus, it is proposed that a basic materialistic conception may underlie students' beliefs and understanding of various physics concepts. [Topics: 2, 5b, 6] 1988-041

Resnick, D. P., & Resnick, L. B. (1985). Standards, curriculum, and performance: A historical and comparative perspective. *Educational Researcher, 14*(4), 5-20.

This article considers how educational standards are established and maintained and how they can be improved in American schools. The authors argue that curriculum (what is taught) and assessment (the way we judge what is learned) together play the largest role in shaping what is demanded in schools and thus what our students can expect to learn. Neither issue has received adequate attention in current debate over the state of our schools and the compelling need for school reform. This article addresses both issues in a historical and comparative perspective, arguing that higher standards are within reach through the development of new and parallel initiatives in curriculum and evaluation. The authors outline potential improvements through upgrading the curriculum, utilizing new forms of assessment, and rethinking the concept of tracking to focus on high standards in the middle school. [Topic: 3] 1985-038

Resnick, D. P., & Resnick, L. B. (1988). Understanding achievement and acting to produce it: Some recommendations for the NAEP. *Phi Delta Kappan, 69*, 576-579.

This article analyzes the National Assessment of Education Progress (NAEP), the 25-year-old report card for U.S. education that is being redesigned. Urging that it be shaped to do more than collect data, the authors stress the need for NAEP to provide information on educational inputs and mediating variables if it is to be of significant use to education policy makers at the state and district levels. Criteria are offered to help determine what additional information should be included, and examples of appropriate input variables are provided with suggestions for more sophisticated analyses of these data. [Topic: 3] 1988-042

Resnick, D. P., & Resnick, L. B. (1989). Varieties of literacy. In A. E. Barnes & P. N. Stearns (Eds.), *Social history and issues in human consciousness: Some interdisciplinary connections* (pp. 171-196). New York: New York University Press.

This chapter stresses the need to consider literacy as a social rather than an individual experience and each literate act as a social act involving a transaction between a writer and reader, through the medium of a text. Understanding the meaning of literacy for its participants, therefore, necessitates analyzing both the nature of texts and the activities and expectations associated with the roles of reader and writer in different literacy transactions. The authors identify six paradigmatic transactions, suggest a framework for comparing and contrasting those relationships, and discuss implications for the current literacy debate and for educational policy. [Topics: 12, 14] 1989-052

Resnick, L. B. (1985). Cognition and instruction: Recent theories of human competence and how it is acquired. In B. L. Hammonds (Ed.), *Psychology and learning: The master lecture series* (Vol. 4, pp. 123-186). Washington, DC: American Psychological Association.

Since researchers in various branches of psychology found common ground in the study of cognition, they have been joined by researchers in other disciplines, forming a new cognitive science research community. These changes have sparked both research on complex forms of knowledge and skill and development of new research methods and forms of theorizing. A new scientific method specifically suited to the study of human mental functioning is gradually emerging. Against that backdrop, this chapter sketches how intellectual competence is acquired in four domains and suggests directions for future research, especially research focused on improving instruction. [Topic: 1] 1985-039

Resnick, L. B. (1985). Instructional psychology. In T. Husen & T. N. Postlethwaite (Eds.), *International encyclopedia of education: Research and studies* (Vol. 5, pp. 2569-2581). Oxford: Pergamon Press.

Instructional psychology is concerned with the processes of learning educational subject matter and with the nature of interventions designed to enhance that learning. This chapter illustrates the major trends and issues in the field by considering cognitive research in four broad areas of direct relevance to the school: reading, mathematics, science, and problem solving. It describes an emerging body of research on aptitude and intelligence that may eventually change conceptions of these individual differences constructs. The chapter also discusses some steps that may be necessary to link cognitive instructional psychology more directly to practical educational concerns. [Topic: 1] 1985-040

Resnick, L. B. (1986). The development of mathematical intuition. In M. Perlmutter (Ed.), *Perspectives on intellectual development: The Minnesota Symposium on Child Psychology* (Vol. 19, pp. 159-194). Hillsdale, NJ: Erlbaum.

Why, despite children's informal mathematical competence, is formal mathematics so difficult for many to learn? Part of that problem appears to emanate from the dual function of mathematical symbols, which refer to both mathematical entities and mathematical abstractions. Mathematical

language, therefore, is both an object of mathematical reasoning and a tool of such reasoning. This chapter considers the nature of children's intuitive knowledge of mathematics, the complexity of coordinating symbols and referents in mathematical development, and the role of each in school mathematics learning. The author concludes with several proposals for future research. [Topic: 10] 1986-038

Resnick, L. B. (1987). *Education and learning to think*. Washington, DC: National Academy Press.

This monograph explores the nature of higher order skills and the changing status of higher order thinking in educational theory and practice. The author examines the teachability of such skills and argues that the notion of basic skills should be modified, because learning to read, write, and do mathematics requires the activation of higher order thinking. She recommends that instruction incorporate this perspective and reflect the advances made in understanding the cognitive processes documented in recent research. The role of educational institutions in cultivating not only skills for thinking but also the disposition to think critically is discussed. [Topic: 1] 1987-053*

Resnick, L. B. (1987). Constructing knowledge in school. In L. S. Liben (Ed.), *Development and learning: Conflict or congruence?* (pp. 19-50). Hillsdale, NJ: Erlbaum.

The arguments developed in this chapter suggest that it is unproductive to assume that there are two different kinds of knowledge acquisition, one for formal and another for informal situations. Although constructive processes are involved in both school learning and informal learning situations, the quality of the constructions depends on the kinds of representations used in reasoning. The author, therefore, discourages focusing on distinctions between learning and development, recommending instead that attention be focused on the processes by which knowledge construction proceeds and on how various environmental stimuli shape and constrain those processes. [Topic: 1] 1987-054

Resnick, L. B. (1987). Instruction and the cultivation of thinking. In E. De Corte, H. Lodewijks, R. P. Parmentier, & P. Span (Eds.), *Learning and instruction: European research in an international context* (Vol. 1, pp. 415-442). Oxford: Leuven University Press/Pergamon Press.

Research in cognition and learning is demonstrating that various mental activities associated with higher order thinking are implicated in all competent mental functioning and that traditional distinctions between higher order thinking and basic skills should be abandoned. The author points out that, although defining higher order thinking is difficult, recognizing when it occurs is not. She lists characteristics of higher order thinking and presents evidence that aspects of mental functioning traditionally excluded from mass education are involved throughout learning. After reviewing programs for teaching higher order skills, the chapter suggests implications for education and research. [Topic: 1] 1987-055

Resnick, L. B. (1987). Learning in school and out. *Educational Researcher, 16*(9), 13-20.

Research on the nature of everyday, practical, real-world intelligence and learning is providing a basis for understanding what distinguishes practical from formal intelligence. Drawing on that work, this article explores four broad contrasts indicating that school is a special place and time for people--discontinuous with daily life and work. The author then considers where and how the economic, civic, and cultural aims of education can best be pursued and whether schooling should be reorganized to take into account what has been learned about the nature of competence in various aspects of our lives. [Topic: 1] 1987-056

Resnick, L. B. (1988). Treating mathematics as an ill-structured discipline. In R. I. Charles & E. A. Silver (Eds.), *The teaching and assessing of mathematical problem solving* (pp. 32-60). Hillsdale, NJ/Reston, VA: Erlbaum/National Council of Teachers of Mathematics.

Educators typically treat mathematics as a field with no open questions and no arguments. Consequently, children often think of mathematics as a collection of symbol manipulation rules, plus some tricks for solving stereotyped story problems, and fail to link symbolic rules to mathematical concepts or to believe that they can construct and defend mathematical ideas. The author considers the role of talk in promoting a different view of mathematics and better competence for quantitative thinking and raises a set of issues for further investigation if mathematics is to be taught as an ill-structured discipline. [Topic: 5a] 1988-043

Resnick, L. B. (1989). Developing mathematical knowledge. *American Psychologist, 44*(2), 162-169.

Recent research has led to a significant reconceptualization of the nature of children's number knowledge development. This article outlines infants' and preschoolers' implicit protoquantitative reasoning schemas and shows how these combine with early counting knowledge to produce mathematical concepts of number. Research on elementary school children's

informal and invented arithmetic is reviewed, and implications for mathematics education are evaluated. [Topic: 5a] 1989-053

Resnick, L. B. (1990). Instruction and the cultivation of thinking. In N. J. Entwistle (Ed.), *Handbook of educational ideas and practices* (pp. 694-707). London: Routledge.
Research in cognition and learning is demonstrating that various mental activities associated with higher order thinking are implicated in all competent mental functioning and that traditional distinctions between higher order thinking and basic skills should be abandoned. The author points out that, although defining higher order thinking is difficult, recognizing when it occurs is not. She lists characteristics of higher order thinking and presents evidence that aspects of mental functioning traditionally excluded from mass education are involved throughout learning. After reviewing programs for teaching higher order skills, the article suggests implications for education and research. [Topic: 1] 1990-059

Resnick, L. B. (1990). Literacy in school and out. *Daedalus, 119*(2), 169-185.
This article examines forms of literacy practice in school and in everyday life and concludes that schools are too isolated from everyday ways of using the written word to serve as the only source of literacy competence in society. To raise our general levels of literacy, it will be necessary to supplement formal literacy instruction by providing young people with literacy apprenticeships in communities, workplaces, and other settings where people use the written word for practical, informational, and pleasurable purposes. [Topics: 12, 14] 1990-060

Resnick, L. B. (Ed.). (1987). *Knowing, learning, and instruction: Essays in honor of Robert Glaser*. Hillsdale, NJ: Erlbaum.
This volume brings together recent research by leading cognitive, developmental, and social psychologists on knowledge construction, the knowledge-dependent nature of learning, and emerging questions about situational and social influences on learning. The assembled chapters emerged from a symposium on cognition and instruction held in honor of the Learning Research and Development Center's twentieth anniversary and are presented as a festschrift for LRDC's founder, Robert Glaser. [Topic: 1] 1989-054*

Resnick, L. B., & Chi, M. T. H. (1988). Cognitive psychology and science learning. In M. Druger (Ed.), *Science for the fun of it: A guide to informal science education* (pp. 24-31). Washington, DC: National Science Teachers Association.
The authors of this chapter consider what parts of Piaget's theory of cognitive development remain central to our understanding of how people think and learn about science and what parts should be modified in light of more recent relevant knowledge. Supported by cognitive research, the authors offer some constructivist principles to guide educational efforts, with suggestions for new approaches to science learning in informal settings that involve the organization of knowledge, elaborative engagement with new knowledge, and tools for developing mental models. [Topic: 1] 1988-044

Resnick, L. B., & Johnson, A. (1988). Intelligent machines for intelligent people: Cognitive theory and the future of computer-assisted learning. In R. S. Nickerson & P. P. Zodhiates (Eds.), *Technology in education: Looking toward 2020* (pp. 139-168). Hillsdale, NJ: Erlbaum.
This chapter considers some of the current and potential efforts in computer assisted instruction (CAI) in light of major themes from cognitive learning theory. The authors review various CAI efforts, considering both the implications of cognitive principles for the development of CAI and the consequences of these developments for theories of learning. They propose a reconceptualization of the place of CAI in the learning process and suggest that artificial intelligence can be useful in education only to the extent that it focuses its attention on extending, rather than replacing, human intelligence. [Topic: 7] 1988-045

Resnick, L. B., & Klopfer, L. E. (Eds.). (1989). *Toward the thinking curriculum: Current cognitive research (1989 Yearbook of the Association for Supervision and Curriculum Development)*. Alexandria, VA/Hillsdale, NJ: Association for Supervision and Curriculum Development/Erlbaum.
Designed as the 1989 yearbook of the Association for Supervision and Curriculum Development (ASCD), this monograph assembles the ideas and recent research findings of 15 researchers and educators aimed at improving school curricula. It lays the groundwork for an approach to curriculum and teaching that is based on recent conceptions of the nature of thinking and has been validated by cognitive research. Thinking and learning are treated not as separate parts of the instructional process but as activities that must be integrated throughout the entire curriculum. [Topic: 1] 1989-055*

Resnick, L. B., & Nelson-Le Gall, S. (1987). Meaning construction in mathematical problem solving. In J. C. Bergeron, N. Herscovics, & C. Kieran (Eds.), *Proceedings of the Eleventh Annual Conference of the*

Psychology of Mathematics Education (Vol. 3, pp. 215-221). Montreal: International Group for the Psychology of Mathematics Education.

This article reports early results of a program of research that aims to improve children's mathematics learning by developing attitudes and strategies that support processes of interpretation and meaning construction in mathematics. The authors have examined processes of socially shared problem solving in which an adult and other children provide scaffolding for individuals' early problem-solving efforts. Different ways of scaffolding problem-solving efforts and building self-monitoring strategies are explored. These studies show that the intimate relationship between conceptual knowledge and problem solving in mathematics sets special constraints for instruction and learning. [Topic: 6] 1987-057

Resnick, L. B., & Omanson, S. F. (1987). Learning to understand arithmetic. In R. Glaser (Ed.), *Advances in instructional psychology* (Vol. 3, pp. 41-95). Hillsdale, NJ: Erlbaum.

This chapter examines the nature of understanding in procedural domains, how understanding is related to performance skill, and how understanding and procedural competence are learned. Although the empirical data of this study focus on subtraction, a domain central to the primary school curriculum, the study itself focuses on the more general principles of learning and understanding that the case of subtraction illustrates and on whether and how understanding may enhance procedural skill. The conclusion considers implications for a general theory of the relationships between conceptual and procedural learning and for approaches to instruction in elementary mathematics. [Topic: 1] 1987-058

Resnick, L. B., & Resnick, D. P. (1990). Tests as standards of achievement in schools. In G. R. Anrig (Ed.), *The uses of standardized tests in American education: Proceedings of the 1989 ETS Invitational Conference* (pp. 63-80). Princeton, NJ: Educational Testing Service.

In this paper, the authors explore the significant links between educational reform and testing in America. They analyze the nature of current educational reform goals and their implications, the assumptions about the nature of knowledge and competence that are built into standardized tests, and the ways in which assessments function as elements in social systems. The authors propose alternative forms of assessment more compatible with educational goals of thinking and reasoning and suggest how these methods can be used in public accountability, instructional guidance, and certification testing. [Topic: 3] 1990-061

Resnick, L. B., & Resnick, D. P. (1991). Assessing the thinking curriculum: New tools for educational reform. In B. R. Gifford & M. C. O'Connor (Eds.), *Changing assessments: Alternative views of aptitude, achievement, and instruction* (pp. 37-75). Boston: Kluwer.

In this chapter, the authors explore the significant links between educational reform and testing in America. They analyze the nature of current educational reform goals and their implications, the assumptions about the nature of knowledge and competence that are built into standardized tests, and the ways in which assessments function as elements in social systems. The authors propose alternative forms of assessment more compatible with educational goals of thinking and reasoning and suggest how these methods can be used in public accountability, instructional guidance, and certification testing. [Topic: 3] 1991-054

Resnick, L. B., Bill, V., Lesgold, S., & Leer, M. (1991). Thinking in arithmetic class. In B. Means, C. Chelemer, & M. S. Knapp (Eds.), *Teaching advanced skills to at-risk students: Views from research and practice* (pp. 27-53). San Francisco: Jossey-Bass.

This chapter describes results of a two-year effort to apply the following assumptions to early mathematics teaching for disadvantaged children: that all children can begin their educational lives engaging in active thinking and problem solving; that, when thinking-oriented instruction is carefully organized for this purpose, children can acquire the traditional basic skills in the process; and that children can acquire and apply the fundamentals of a discipline and believe in their own capacities as learners and thinkers. Based on achievement test data, interviews, class observations, and school reports, the program appeared effective for children of all ability levels. [Topic: 5a] 1991-055

Resnick, L. B., Cauzinille-Marmeche, E., & Mathieu, J. (1987). Understanding algebra. In J. A. Sloboda & D. Rogers (Eds.), *Cognitive processes in mathematics* (pp. 169-203). Oxford: Clarendon Press.

What does it mean to understand an algebra expression or an algebra rule? What roles does understanding play in children's learning of algebra? These questions motivated the research reported here, which is devoted to discovering the extent to which children beginning to learn algebra are able to relate formal expressions to their situational and conceptual referents. The authors conclude that the challenge of learning

algebra is both to relate the formalisms to the situations and mathematical principles that give them referential meaning and to construct an understanding of algebra as a powerful formal system that contains its own internal meaning. [Topic: 5a] 1987-059

Resnick, L. B., Lesgold, S., & Bill, V. (1990). From protoquantities to number sense. In G. Booker, J. Cobb, & T. N. de Mendicuti (Eds.), *Proceedings of the Fourteenth Psychology of Mathematics Education Conference* (Vol. 3, pp. 305-311). Mexico City, Mexico: International Group for the Psychology of Mathematics Education.

The research described in this article explores the efficacy of an early mathematics program that is aimed at developing number sense and is built entirely on children's invented procedures and on their informally acquired quantitative knowledge. In an effort to socialize children to think of themselves as reasoners about number, the classroom program routinely provided daily conversation about numbers and attention to quantitative examples in everyday situations. First year results show that the program produced large improvements in number sense and in conceptual competence across all ability levels. [Topic: 5a] 1990-062

Resnick, L. B., Levine, J. M., & Teasley, S. D. (Eds.). (1991). *Perspectives on socially shared cognition*. Washington, DC: American Psychological Association.

This volume is about a phenomenon that seems almost a contradiction in terms: cognition that is not bounded by the individual brain or mind. In most psychological research, social and cognitive processes have been studied separately. Aiming to integrate these processes, this book looks beyond psychology to related disciplines that have traditionally taken a less individualistic view of human behavior. The result is a survey of recent work from several disciplines that seeks to merge the social and cognitive perspectives. [Topic: 14] 1991-056*

Resnick, L. B., Nesher, P., Leonard, F., Magone, M., Omanson, S., & Peled, I. (1989). Conceptual bases of arithmetic errors: The case of decimal fractions. *Journal for Research in Mathematics Education, 20*(1), 8-27.

Examining children's efforts to make sense of new mathematics instruction, this article documents major categories of errors that appear consistently as children learn decimal fractions. It then establishes the conceptual sources of these errors. Whole number errors derive from children's applying rules for interpreting multidigit integers. Fraction errors derive from children's efforts to interpret decimals as fractions. Different curriculum sequences influence the probability that these classes of errors will appear. It is suggested that errors are a natural concomitant of students' attempts to integrate new material with established knowledge. [Topic: 5a] 1989-056

Resnick, L. B., Salmon, M. H., & Zeitz, C. M. (1991). The structure of reasoning in conversation. *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society* (pp. 388-393). Hillsdale, NJ: Erlbaum.

This methodologically oriented article focuses on the reasoning that occurs in discussions of controversial social issues by groups of peers in informal settings. In the project reported here, rather sophisticated argument structures emerged and conversational interaction stimulated the development of arguments. Both a system for coding elements of reasoning and a method for displaying the interactive structure of reasoning in conversations were developed. With these tools, further analysis can help expose how people reason cooperatively in social settings. [Topic: 6] 1991-057

Rieben, L., & Perfetti, C. A. (Eds.). (1991). *Learning to read: Basic research and its implications*. Hillsdale, NJ: Erlbaum.

This book contains chapters by different authors discussing how children learn to read and how children are taught to read. Principles and theories of reading, especially the importance of phonological factors, are covered in the initial chapters. Very early reading, phonological abilities and reading disabilities are discussed in the body of the book. [Topic: 5c] 1991-058*

Robin, N., & Ohlsson, S. (1989). Impetus then and now: A detailed comparison between Jean Buridan and a single contemporary subject. In D. E. Herget (Ed.), *The history and philosophy of science in science teaching. Proceedings of the First International Conference* (pp. 292-305). Tallahassee: Florida State University, Science Education & Department of Philosophy.

Different researchers have proposed different hypotheses about the content of common sense beliefs, about their relations to historical theories in physics, and about the reasoning processes available to scientifically naive persons. In this article, the authors apply a four-step method to the analysis of a single interview protocol. The results show that the subject believes in a version of the impetus theory, that her theory overlaps with the theory proposed by Buridan but is nevertheless not identical to it, and that the subject is able to reason theoretically. [Topics: 2, 5b, 6] 1989-057

Roth, S. F., & Beck, I. L. (1987). Theoretical and instructional implications of the assessment of two microcomputer word recognition programs. *Reading Research Quarterly, 22*(2), 197-218.
This article assessed the effectiveness of two microcomputer programs for improving word recognition/decoding skills, and the extent to which decoding improvements lead to improvements in reading comprehension. Findings were substantial improvements in decoding skill and comprehension at the word and sentence level, but no comprehension improvement at the passage level. [Topics: 7, 12, 16] 1987-060

Saltrick, D. S., Johnson, J. A., & Bickel, W. E. (1991). Establishing organization development strategies in secondary schools. *Journal of Staff Development, 12*(1), 52-55.
This article describes the use and value of staff capacity-building as a mechanism for organizational development. [Topic: 4] 1991-059

Sansone, J., & Zigmond, N. (1986). Evaluating mainstreaming in urban elementary schools through an analysis of students' weekly schedules. *Exceptional Children*, 52(5), 452-458.
This article describes a comprehensive study which has as its purpose to help a large urban school district evaluate and improve its mainstreaming practices. Schedules of 844 mildly handicapped elementary school students were analyzed to describe the degree of appropriateness of each school's mainstreaming practices. Then, school variables were investigated in relation to appropriate scheduling. [Topic: 17] 1986-039

Schaeffer, A. L., Kerr, M. M., Zigmond, N., & Farra, H. E. (1989). Helping teenagers develop school survival skills. *TEACHING Exceptional Children*.
Many parents don't know what to do to help their adolescents in school. In a recent survey conducted in three urban high schools, the authors asked principals, school administrators, teachers, school personnel and over 4,000 students to identify skills that are critical for success in high school and to identify serious problems that contribute to difficulty in high school. This article provides suggestions to improve these school survival skills and eliminate school survival problems. [Topic: 17] 1989-058

Schauble, L. (1990). Belief revision in children: The role of prior knowledge and strategies for generating evidence. *Journal of Experimental Child Psychology, 49*(1), 31-57.
This article reports on a study that examined the relation between evolving beliefs and reasoning strategies in 22 fifth- and sixth-grade children who worked over 8 weeks for a total of about 5 hours on a causal reasoning problem. Exploratory strategies improved as children exercised them over time, but invalid heuristics that preserved children's favored theories were evident throughout. Those children using more valid strategies achieved more complete, stable comprehension of the structure of the problem. In turn, children used their beliefs to make meaning of the complex patterns of evidence they observed. [Topic: 11] 1990-063

Schauble, L. (1990). Formative evaluation in the design of educational software at the Children's Television Workshop. In B. N. Flagg (Ed.), *Formative evaluation for educational technologies* (pp. 51-66). Hillsdale, NJ: Erlbaum.
A description is given of a unique model of research and development formulated by the Children's Television Workshop for the creation of interactive educational technologies for children. [Topic: 7] 1990-064

Schauble, L., & Glaser, R. (1990). Scientific thinking in children and adults. In D. Kuhn (Ed.), *Developmental perspectives on teaching and learning thinking skills: Contributions to human development* (Vol. 21, pp. 9-27). Switzerland: Karger.
A program of research on the use of scientific thinking skills in contexts of self-directed experimentation is described. Scientific reasoning is studied here in domains rich enough that prior beliefs significantly affect the reasoning process. The authors also continue a recent trend of investigating larger, coherent episodes of reasoning that occur over an extended period of time and that include the full cycle of hypothesis generation, experimentation, data interpretation, and hypothesis revision. The performance of adults is compared with the performance of children on these tasks. [Topics: 5b, 6, 11] 1990-065

Schauble, L., Glaser, R., Raghavan, K., & Reiner, M. (1991). Causal models and experimentation strategies in scientific reasoning. *The Journal of the Learning Sciences, 1*(2), 201-238.
The study described in this article explores how novices' conceptions of electric circuits affected their self-directed experimentation in a computer-based laboratory. The participants were 22 undergraduates with no formal college instruction in physics. Relations were found between students' causal models of circuits and their learning gains in the computer laboratory. In general, sophisticated models that had been identified in an independent problem solving task were related to sophisticated reasoning in the computer discovery task. [Topics: 2, 6, 10] 1991-060

Schauble, L., Klopfer, L. E., & Raghavan, K. (1991). Students' transition from an engineering model to a science model of experimentation. *Journal of Research in Science Teaching, 28*(9), 859-882.
The study reported in this article investigates the hypothesis that when children are engaged in science experiments, where the goal is to understand the relations among causes and effects, they often use the engineering model of experimentation, characterized by the more familiar goal of manipulating variables to produce a desired outcome. Sixteen fifth- and sixth-graders worked on two experimentation problems consistent with the science and engineering models, respectively. The science model was associated with broader explanation, more selectiveness about the evidence generated, and greater attention to establishing that some variables are not causal. [Topics: 5b, 6, 11] 1991-061

Schiano, D. J., Cooper, L. A., Glaser, R., & Zhang, H. C. (1989). Highs are to lows as experts are to novices: Individual differences in the representation and solution of standardized figural analogies. *Human Performance, 2*(4), 225-248.
Findings are reported from two experiments that compared the strategies used by high and low scorers on standardized figural analogy tests to represent and solve problems. The findings converge to suggest specific aptitude-related differences in the representation and solution of standardized figural analogy problems. These differences resemble expert-novice differences in a number of other problem solving domains. [Topics: 3, 13] 1989-059

Schneider, W. (1985). Toward a model of attention and the development of automatic processing. In M. Posner & O. S. Marin (Eds.), *Attention and performance XI* (pp. 475-492). Hillsdale, NJ: Erlbaum.
A model for the development of automatic processing is briefly described in this chapter. The model is a quasineural one in which information processing is done through the transmission of vectors between visual, lexical, semantic, and motor processing units. Controlled processing involves gating of the output power of vectors to perform matches and to release response vectors. As subjects practice consistent tasks, associative learning enables an input vector to evoke an output vector and priority learning determines the power with which a vector is transmitted. Automatic processing involves a cascade of vector transmissions in which the output power of each transmission is determined by the priority learning. The transition from controlled to automatic processing takes place in four phases. Empirical illustrations of thin transition are described. [Topic: 19] 1985-041

Schneider, W. (1985). Training high-performance skills: Fallacies and guidelines. *Human Factors, 27*(3), 285-300.
A high performance skill is one in which (1) more than 100 hours of training are required, (2) substantial numbers of individuals fail to develop proficiency, and (3) the performance of the expert is qualitatively different from that of the novice. Training programs for developing high-performance skills are often based on assumptions used for simple skills and can be fallacious. Common fallacies include: long acquisition period; heterogeneity of component learning; development of inappropriate strategies; and training of time-sharing skills. A set of guidelines for acquisition of high-performance skills is described. [Topic: 19] 1985-042

Schneider, W. (1987). Connectionism: Is it paradigm shift for psychology? *Behavioral Research Methods, Instruments, & Computers, 19*(2), 73-83.
Connectionism is a method of modeling cognition as the interaction of neuron-like units. Connectionism has received a great deal of interest and may represent a paradigm shift for psychology. The nature of a paradigm shift is reviewed with respect to connectionism. The reader is provided an overview on connectionism including: an introduction to connectionist modeling; new issues it emphasizes; a brief history; its developing sociopolitical impact; its theoretical impact; and its empirical impact. Cautions, concerns, and enthusiasm for connectionism are expressed. [Topic: 19] 1987-061

Schneider, W. (1988). Micro Experimental Laboratory: An integrated system for IBM PC compatibles. *Behavior Research Methods, Instruments, & Computers, 20*(2), 206-217.
This article describes the Micro Experimental Laboratory (MEL), a third-generation integrated software system for experimental research. The researcher fills in forms, and MEL writes the experimental program, runs the experiments, and analyzes the data. MEL includes a form-based user interface, automatic programming, computer tutorials, a compiler, a real-time data acquisition system, database management, statistical analysis, and subject scheduling. It can perform most reaction time, questionnaire, and text comprehension experiments with little or no programming. It includes a Pascal-like programming language and can call routines written in standard languages. MEL operates on IBM PC compatible computers, supports most

display controllers, and maintains millisecond timing with high-speed text and graphics presentation. MEL provides a systematic approach to dealing with nine concerns in running an experimental laboratory. [Topic: 7] 1988-046

Schneider, W. (1988). Sensitivity analysis in connectionist modeling. *Behavior Research Methods, Instruments, & Computers*, 20(2), 282-288.
The application of sensitivity analysis methodology to connectionist modeling is discussed in this article. Sensitivity analysis examines the functional relationship of parameters in dynamic systems to specify the interactions of parameters and the boundary conditions of dynamic system models. Sensitivity analysis is contrasted with parameter estimation. Reasons to favor sensitivity analysis in connectionist modeling are discussed. Six steps for sensitivity analysis are detailed with examples from the modeling of short- and long-term memory retrieval. [Topic: 19] 1988-047

Schneider, W. (1988). Structure and controlling subsymbolic processing. *Behavior and Brain Sciences*, *11*, 51-52.
This article is a commentary on Smolensky: Proper treatment of connectionism. It discusses different forms of hybrid connectionist/symbolic processing. [Topic: 19] 1988-048

Schneider, W. (1989). Enhancing a standard experimental delivery system (MEL) for advanced psychological experimentation. *Behavior Research Methods, Instruments, & Computers*, *21*(2), 240-244.
Enhancements to the Micro Experimental Laboratory (MEL) and the ways in which they facilitate development of psychological experiments are discussed in this article. New procedures are described for (1) presenting and manipulating pictorial graphics, (2) inputting response box, voice key, joystick, digitized speech, and mouse responses, (3) outputting lights, speech, and tone stimuli, (4) editing and analyzing digitized speech, and (5) implementing multitask processing. Methods for extending the language, developing test batteries, sequencing subjects, and managing and analyzing data are described. [Topic: 7] 1989-060

Schneider, W. (1989). Tutorial: Computer viruses: What they are, how they work, how they might get you, and how to control them in academic institutions. *Behavior Research Methods, Instruments, & Computers*, *21*(2), 334-340.
A computer virus is a program that replicates itself and spreads to computers with the goal of disrupting or destroying normal computer use. In academic computing, viruses represent a serious problem that costs millions of dollars in losses annually and hinders the free exchange of information so critical to education. Viruses operate in incubation, infection, and destroy phases. The nature, mechanisms, and preventive measures for personal-computer viruses are reviewed. Different procedures are recommended to protect research laboratories, instructional laboratories, and software lending libraries. Tradeoffs between providing adequate protection and not having the security become too burdensome are considered. [Topic: 7] 1989-061

Schneider, W. (1990). Training models to estimate training costs for new systems. In J. I. Elkind, S. K. Card, J. Hochberg, & B. M. Huey (Eds.), *Human performance models for computer-aided engineering* (pp. 215-232). San Diego, CA: Academic Press.
This chapter reviews methods for estimating training costs for new systems and models of skill acquisition. It reviews how performance changes through automization. Techniques to predict performance after training are described. The simulation techniques of production system modeling, connectionist modeling and hybrid architectures are illustrated. The limitations of the techniques suggest that the application to engineering will require rapid prototyping and quick empirical evaluations to determine the parameters of models. Directions for future research are suggested. [Topic: 19] 1990-066

Schneider, W. (1991). Equipment is cheap but the field must develop and support common software for psychological research. *Behavior Research Methods, Instruments, & Computers*, *23*(2), 114-116.
Over the last 18 years, the commercial sector has provided psychology with very advanced equipment at low cost. It is unlikely, however, that the commercial sector will provide psychology with the special-purpose software that is needed for data acquisition. Software costs are now the greatest cost of data acquisition. Psychology needs common software used by many researchers. This article emphasizes the need for efforts and funds to be concentrated so that comprehensive software systems can be developed and supported. Software systems should provide open architectures to allow individual researchers to add specialized functions within an integrated environment. [Topic: 7] 1991-062

Schneider, W., & Detweiler, M. (1986). Changes in performance in workload with training. *Proceedings of the Human Factors Society* (Vol. 2, pp. 1128-1132). Santa Monica, CA: Human Factors Society.
The effects of practice on accuracy, speed, and resource load are briefly discussed in this article.

Procedures for measuring resource load and training of high performance skills are illustrated. Analysis of task consistency and procedures for establishing the marginal utility of various training options are described. The authors comment on the alternatives of time-line analysis, subjective measures and multiple resource theory. [Topic: 19] 1986-040

Schneider, W., & Detweiler, M. (1987). A connectionist/control architecture for working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 21, pp. 53-119). New York: Academic Press.

A runnable simulation architecture for working memory is described that provides an alternative to existing models for working memory. It is used to interpret a variety of phenomena, including multiple resources, workload, chunking, sequential output, skilled and episodic memories, and stages of skill acquisition. The architecture is based on a set of modules organized into regions which communicate with each other on an innerloop of processing. A new feature of this architecture is a proposed context-storage module that temporarily stores context information in fast changing connection weights. This enables the system to expand effective working memory beyond the traditional 7+/-2 items. The context storage system is able to reload modules after short-term information decays or is displaced; in addition, it provides a means of achieving stable, robust processing under conditions of high workload. [Topic: 9, 19] 1987-062

Schneider, W., & Detweiler, M. (1988). The role of practice in dual-task performance: Toward workload modeling in a connectionist/control architecture. *Human Factors*, 30(5), 539-566.

The literature on practice effects and transfer from single- to dual-task performance is briefly reviewed in this article. The review suggests that single-task training produces limited transfer to dual-task performance. Past theoretical frameworks to explain multitask performance are reviewed and a connectionist/control architecture for skill acquisition is presented. The architecture involves neural-like units at the micro level of processing, with information transmitted between modules at the macro level. Seven compensatory activities occur in the architecture during dual-task training that do not appear in single-task training: (1) shedding and delaying tasks and preloading buffers; (2) letting go of high-workload strategies; (3) utilizing noncompeting resources; (4) multiplexing over time; (5) shortening transmissions; (6) converting interference from concurrent transmissions; and (7) chunking of transmission. [Topic: 19] 1988-049

Schneider, W., & Oliver, W. L. (1991). An instructable connectionist/control architecture: Using rule-based instructions to accomplish connectionist learning in a human time scale. In K. Van Lehn (Ed.), *Architectures for intelligence* (pp. 113-145). Hillsdale, NJ: Erlbaum.

The nature and relative strengths of symbolic versus connectionist processing are reviewed in this chapter. The problem of scaling of learning time is considered with connectionist learning being much slower than humans and symbolic learning much faster than human learning. A hybrid architecture for learning of digital logic gates is described. By providing a method of decomposing the problem, exponential increases in learning time as a function of complexity can become linear increases. The hybrid system learns much faster than standard connectionist systems. The CAP2 architecture that allows modular connectionist processing with a recurrent rule net is described. A combination of task decomposition and rule learning provides a good match for the human data. The results are interpreted as indicating that hybrid connectionist/control models have significant computational advantages over purely connectionist or pure symbolic systems. [Topic: 9] 1991-063

Schneider, W., & Shiffrin, R. M. (1985). Categorization (restructuring) and automation: Two separable factors. *Psychological Review*, 92(3), 424-428.

Cheng (1985) presented a hypothesis concerning categorization that was supposed to provide an alternative to the automatization hypothesis of Schneider and Shiffrin (1977; Shiffrin & Schneider, 1977). In 1977, the authors carried out several critical studies showing that the categorization hypothesis was correct, but also showing conclusively that it and several related hypotheses were insufficient to explain a number of key findings. Although Cheng's review either did not discuss or appropriately discounted the evidence, the 1977 articles and more recent ones provide a definitive demonstration of automatization. [Topic: 19] 1985-043

Schofield, J. W. (1986). Black-white contact in desegregated schools. In M. Hewstone & R. Brown (Eds.), *Contact and conflict in intergroup encounters* (pp. 79-92). Oxford, England: Basil Blackwell.

This chapter discusses second generation problems in desegregated schools including (a) the tendency toward resegregation, (b) the emergence of new

and subtle forms of racism, and (c) disagreement over the goals of desegregation. It concludes by considering the implications of this analysis for policy and practice. [Topics: 4, 8, 14] 1986-041

Schofield, J. W. (1986). Causes and consequences of the colorblind perspective. In S. Gaertner & J. Dovidio (Eds.), *Prejudice, discrimination and racism: Theory and practice* (pp. 231-253). New York: Academic Press.

This chapter, based on an intensive four-year qualitative study of a desegregated middle school, examines the causes and consequences of the colorblind perspective--a view endorsed by the school's administrators and teachers which holds that the school and its staff should ignore race completely, treating it as a completely irrelevant individual characteristic. The adoption of this perspective reduced the potential for overt racial conflict; minimized initial awkwardness, discomfort, and embarrassment between individuals from different racial groups; and increased teachers' freedom of action in both constructive and destructive ways. It also had a number of largely unrecognized negative consequences, which included (a) promoting a climate conducive to aversive racism and (b) failure to respond to, and capitalize on, the diversity of the student body. [Topics: 4, 8, 14] 1986-042

Schofield, J. W. (1988). Social relations in desegregation. *Equity and Choice, 4*, 15-17.

The importance of thinking about desegregation as an ongoing process rather than a one-time event is emphasized in this article. In planning to maximize the chances that this process will have positive outcomes, it is useful to recognize the importance of structuring desegregated schools so that minority and majority group members (a) have equal status within the school, (b) are encouraged to cooperate with each other for mutually valued goals, and (c) understand clearly that the relevant school authorities, including both teachers and administrators, support the goal of desegregation. [Topics: 4, 8, 14] 1988-050

Schofield, J. W. (1988). The analysis of qualitative data [Review of *Qualitative analysis for social scientists*]. *Contemporary Psychology, 33*(12), 1056-1058.

This article is a review of Anselm Strauss' book *Qualitative Analysis for Social Scientists*. New York: Cambridge University Press. It discusses the increasing acceptance of qualitative methodology in a variety of disciplines and the need for careful expositions of the data analytic procedures used by qualitative researchers. [Topic: 3] 1988-051

Schofield, J. W. (1990). Increasing the generalizability of qualitative research. In E. W. Eisner & A. Peshkin (Eds.), *Qualitative inquiry in education* (pp. 201-232). New York: Teachers College Press.

A shift in the last few decades in both the purpose and locale of much qualitative research has contributed to an increasing interest in generalizability. New conceptions of generalizability which fit this kind of work have been emerging. This chapter contributes to this process by exploring the kinds of things qualitative researchers want to generalize to and how research can be designed to increase the possibility that such generalization is warranted. It argues that qualitative researchers are often interested in trying to generalize to (a) what is, (b) what may be, and (c) what could be. It then discusses design practices likely to enhance the generalizability of qualitative studies. [Topic: 3] 1990-067

Schofield, J. W. (1991). School desegregation and intergroup relations: A review of the literature. In G. Grant (Ed.), *Review of research in education* (Vol. 17, pp. 335-409). Washington, DC: American Educational Research Association.

This comprehensive review of the literature discusses research on school desegregation and intergroup relations from the 1950's until 1990. It summarizes the conclusions emerging from this research and analyzes the methodological and conceptual underpinnings of this work at different periods. [Topic: 8] 1991-064

Schofield, J. W., & Anderson, K. (1987). Combining quantitative and qualitative components of research on ethnic identity and intergroup relations. In J. S. Phinney & M. J. Rotheram (Eds.), *Children's ethnic socialization: Pluralism and development* (pp. 252-273). Newbury Park, CA: Sage.

This chapter compares qualitative and quantitative approaches to research, focusing especially on research on ethnic identity and intergroup relations. It calls for a rapprochement between the two methods, then proceeds to suggest a number of ways in which qualitative approaches to research can be strengthened by incorporating practices more typical of quantitative approaches without undercutting the strengths typical of these approaches. [Topic: 3] 1987-063

Schofield, J. W., & Evans-Rhodes, D. (1989). Artificial intelligence in the classroom: The impact of a computer-based tutor on teachers and students. In D. Bierman, J. Breuker, & J. Sandberg (Eds.), *Artificial Intelligence and Education: Proceedings of the Fourth International Conference on AI and Education* (pp. 238-243). Amsterdam, Netherlands: IOS.

The study described in this chapter assessed the impact of utilization of an artificially intelligent geometry proof tutor on classroom social processes. Both teachers' and students' behaviors changed. Teachers devoted more time to their slower students treated students in a more collegial fashion, and increased their emphasis on effort in grading students. Students showed a marked increase in task-related effort and involvement. This change appeared to be due to an increase both in the students' enjoyment of the class and in the level of peer competition. [Topic: 7] 1989-063

Schofield, J. W., & Pavelchak, M. (1985). *The Day After*: The impact of a media event. *American Psychologist, 40*(5), 542-548.
This article discusses the impact of the TV movie *The Day After* on the American public. It argues that the widespread belief that the film had no effect was incorrect. The belief was fostered by unrealistic expectations that the film would have an overwhelming impact combined with national polls which focused on the movie's impact on issues of immediate political interest rather than on the kinds of changes which social psychological theory suggest are likely. The article presents data suggesting that *The Day After* had a substantial impact, most especially on the salience of nuclear issues in the minds of citizens. [Topics: 7, 14] 1985-044

Schofield, J. W., & Pavelchak, M. A. (1989). Fallout from *The Day After*: The impact of a TV film on attitudes related to nuclear war. *Journal of Applied Social Psychology, 19*(5), 433-448.
This article reports on a household survey, designed to assess the impact of the TV movie, *The Day After*. The data showed that the movie and the surrounding controversy had a substantial impact on the salience of nuclear war, feelings of personal efficacy, affect related to the idea of a nuclear war, intentions to engage in anti-nuclear behavior, estimates of the probability that a nuclear war would occur, and beliefs about the desirability of survival. The post-airing survey found more passive affective reactions to the idea of nuclear war, decreased estimates of the chances of survival, a decreased desire to survive, and a decreased sense of personal efficacy. Nonetheless, respondents, especially those who watched *The Day After*, were more likely to intend to engage in anti-nuclear war activities after the film than before. [Topic: 7] 1989-064

Schofield, J. W., & Verban, D. (1988). *Barriers and incentives to computer usage in teaching* (Tech. Rep. No. 1). Pittsburgh, PA: University of Pittsburgh, LRDC.
This report describes an intensive, qualitative two-year study of computer usage in an urban high school which suggested many barriers to the utilization of microcomputers including (a) teachers' lack of clarity about why and how computers can be used in various fields, (b) teachers' lack of familiarity with computer hardware and software, (c) the overload of knowledgeable teachers, (d) inertia, and (e) the threat that the process of learning about and using computers posed to many teachers' sense of competence. Incentives leading to computer usage were fewer and weaker. They included (a) teachers' belief that important instructional goals could best be met through computer usage, (b) teachers' own personal enjoyment of computer usage, and (c) administrators' belief that computers were useful as a public relations tool. The study also concluded that when computer usage does occur, it markedly influences important aspects of classroom structure and functioning. [Topics: 4, 7] 1988-052

Schofield, J. W., & Verban, D. (1988). Computer usage in the teaching of mathematics: Issues which need answers. In D. A. Grouws & T. J. Cooney (Eds.), *Effective mathematics teaching* (Vol. 1, pp. 169-193). Hillsdale, NJ/Reston, VA: Erlbaum/National Council of Teachers of Mathematics.
This chapter reports on an intensive, qualitative two-year study of computer usage in an urban high school which suggested many barriers to the utilization of microcomputers, including (a) teachers' lack of clarity about why and how computers can be used in various fields, (b) teachers' lack of familiarity with computer hardware and software, (c) the overload of knowledgeable teachers, (d) inertia, and (e) the threat that the process of learning about and using computers posed to many teachers' sense of competence. Incentives leading to computer usage were fewer and weaker. They included: (a) teachers' belief that important instructional goals could best be met through computer usage, (b) teachers' own personal enjoyment of computer usage, and (c) administrators' belief that computers were useful as a public relations tool. The study also concluded that when computer usage does occur, it markedly influences important aspects of classroom structure and functioning. [Topics: 4, 7] 1988-053

Schofield, J. W., Evans-Rhodes, D., & Huber, B. R. (1990). Artificial intelligence in the classroom: The impact of a computer-based tutor on teachers and students. *Social Science Computer Review, 8*(1), 24-41.

The study described in this article assessed the impact of utilization of an artificially intelligent geometry proof tutor on classroom social processes. Both teachers' and students' behaviors changed. Teachers devoted more time to their slower students treated students in a more collegial fashion, and increased their emphasis on effort in grading students. Students showed a marked increase in task-related effort and involvement. This change appeared to be due to an increase both in the students' enjoyment of the class and in the level of peer competition. [Topic: 7] 1990-068

Schooler, J. W. (1991). Review of *Varieties of memory and consciousness: Essays in honor of Endel Tulving*. *Applied Cognitive Psychology, 4*, 536-537.
This is a book review of H. L. Roediger & F. I. Craik (Eds.). 1989. *Varieties of Memory and Consciousness: Essays in Honor of Endel Tulving*. Hillsdale, NJ: Erlbaum. It is suggested that part of the reason for disagreement over what memory systems exist may result because of confusion over what constitutes a memory system. [Topic: 9] 1991-087

Schooler, J. W. (1991). Why do we forget? What can we do about it? *The 1991 World Book Year Book* (pp. 120-133). Chicago, IL: World Book, Inc.
This article summarizes for the general public recent research on the causes for forgetting and techniques for improving memory. [Topic: 9] 1991-065

Schooler, J. W., & Engstler-Schooler, T. Y. (1990). Verbal overshadowing of visual memories: Some things are better left unsaid. *Cognitive Psychology, 22*, 36-71.
It is widely believed that verbal processing generally improves memory performance. However, in a series of six experiments, verbalizing the appearance of previously seen visual stimuli impaired subsequent recognition performance. This collection of results is consistent with a recoding interference hypothesis: verbalizing a visual memory may produce a verbally biased memory representation that can interfere with the application of the original visual memory. [Topic: 9] 1990-069

Schooler, J. W., & Loftus, E. F. (1987). Memory. *The McGraw-Hill encyclopedia of science and technology* (Vol. 1, pp. 584-587). New York: McGraw-Hill.
This article is a summary of basic memory processes, written at a level that can be easily understood by the public. [Topic: 9] 1987-073

Schooler, J. W., & Tanaka, J. W. (1991). Composites, compromises, and CHARM: What is the evidence for blend memory representations? *Journal of Experimental Psychology: General, 120*(1), 96-100.
This article reviews evidence for blend memory representations. It is concluded that currently surprisingly little evidence directly supports this hypothesized type of memory representation. [Topic: 9] 1991-066

Schooler, J. W., Clark, C. A., Loftus, E. F. (1988). Knowing when memory is real. In M. M. Gruneberg, P. Morris, & R. N. Sykes (Eds.), *Practical aspects of memory* (pp. 83-88). New York: Wiley.
In past work, the authors compared descriptions written by subjects who had seen an object (accurate descriptions) with those produced by subjects who falsely believed they had seen the same object (inaccurate descriptions). A major finding was that accurate descriptions mentioned more sensory detail while inaccurate descriptions included more thought processes. In a new study, transcripts of subjects' spoken protocols showed that accurate and inaccurate memory descriptions differed in these same ways. [Topic: 9] 1988-054

Schooler, J. W., Foster, R. A., & Loftus, E. F. (1988). Some deleterious consequences of the act of recollection. *Memory and Cognition, 16*(3), 243-251.
This article reports on two experiments which investigated the impact of responding to recognition test items that do not include a correct alternative. The results suggest that committing to a distractor causes subjects to remember a false detail that can interfere with their later ability to access the original information. [Topic: 9] 1988-055

Scott-Jones, D., & Nelson-Le Gall, S. (1986). Defining black families: Past and present. In E. Seidman & J. Rappaport (Eds.), *Redefining social problems* (pp. 83-100). New York: Plenum.
This chapter provides a reassessment of the nature of black families in the United States. Frequently noted differences in the structure and functioning of black and white families are examined and the origin, extent, and meaning of these differences are discussed. By applying a cultural-ecological model that considers family structure and functioning in context, rather than in simple comparison to a presumed standard, it is demonstrated that the way in which research is approached can change the type of data collected and the interpretation of that data, including issues of causal directions of relationships often left implicit. [Topic: 14] 1986-043

Segal, J. W., Chipman, S. F., & Glaser, R. (Eds.). (1985). *Thinking and learning skills: Relating instruction to research* (Vol. 1). Hillsdale, NJ: Erlbaum.

This volume, a collection of reports on major instructional programs that aim to foster higher order thinking skills, constitutes a survey of the research for innovations in teaching thinking skills and thus sheds light on major debates about the generality of such skills and their transfer across domains. [Topics: 5c, 6, 16] 1985-045*

Shedden, J. M., & Schneider, W. (1990). A connectionist model of attentional enhancement and signal buffering. *Proceedings of the Twelfth Annual Conference of the Cognitive Science Society* (pp. 566-573). Hillsdale, NJ: Erlbaum.
The connectionist/control simulation of attentional enhancement, signal maintenance, and buffering of information is described in this article. It implements a hybrid connectionist architecture incorporating auto-association in the hidden layer and gain control on the hidden and output layer. The model's structure parallels major features of modular cortical structure. The attentional selection simulations show that as one channel is attenuated, the system exhibits attentional capture in which only the more intense stimulus is transmitted to higher levels. The signal maintenance simulations show that small levels of auto-associative feedback can faithfully maintain short bursts of input for extended periods of time. With high auto-associative feedback, one module can buffer information from a previous transmission while the module blocks the interference resulting from concurrent ones. The combination of auto-associative feedback and gain control allow extensive control of information flow. [Topic: 19] 1990-070

Shedden, J. M., & Schneider, W. (1991). A connectionist simulation of attention and vector comparison: The need for serial processing in parallel hardware. *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society* (pp. 546-551). Hillsdale, NJ: Erlbaum.
Given the massively parallel nature of the brain, an obvious question is why are so many information processing functions serial? In particular, this article addresses the issue of the comparison process. Behavioral data show that in perceptual matching tasks (such as memory scanning and visual search) performance is systematically affected by stimulus load, in that required processing time increases with each additional comparison item. It is arguable whether this indicates a processing system that performs serial comparisons, or a system for which comparisons are done in parallel but reaction time is affected by load because of other system limitations. In this simulation, the authors show that in a modular connectionist system, vector transmission is possible in parallel, but the comparison process within a module must be done serially unless accuracy is sacrificed. [Topic: 19] 1991-067

Shute, V. J., & Glaser, R. (1990). A large-scale evaluation of an intelligent discovery world: Smithtown. *Interactive Learning Environments*, *1*(1), 51-77.
An evaluation of Smithtown, a tutoring system designed to enhance an individual's scientific inquiry skills and to provide an environment for learning principles of basic microeconomics, is reported in this article. Two studies of individual differences in learning were conducted. Differentiating behaviors mirrored differences shown in studies of general problem solving and concept formation. [Topics: 1, 5b, 5d, 7] 1990-071

Shute, V. J., Glaser, R., & Raghavan, K. (1989). Inference and discovery in an exploratory laboratory. In P. L. Ackerman, R. J. Sternberg, & R. Glaser (Eds.), *Learning and individual differences: Advances in theory and research* (pp. 279-326). New York: Freeman.
The research described in this chapter employs a computer laboratory called Smithtown to study students' inductive inquiry skills. Students' effectiveness generally in collecting, organizing, and understanding data, concepts, and relationships in economics was shown to vary with their success in mastering domain information. [Topics: 1, 5b, 5d, 7] 1989-065

Shute, V., & Glaser, R. (1991). An intelligent tutoring system for exploring principles of economics. In R. E. Snow & D. Wiley (Eds.), *Improving inquiry in social science: A volume in honor of Lee J. Cronbach* (pp. 333-366). Hillsdale, NJ: Erlbaum.
This chapter describes the development of an intelligent tutoring system designed to investigate students' problem solving and induction skills as well as their acquisition of knowledge of principles of economics. The microworld can detect effective and ineffective inquiry strategies by comparing student actions with optimal action sequences. Furthermore, the chapter discusses a partially implemented coach that can teach the inquiry strategies in the context of the domain knowledge. [Topics: 1, 5b, 5d, 7] 1991-068

Silver, E. A. (1987). Foundations of cognitive theory and research for mathematics problem-solving instruction. In A. H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 33-60). Hillsdale, NJ: Erlbaum.
In recent years, mathematics educators have become more interested in increasing students' ability to use and apply mathematical knowledge learned in school for solving problems both within

and outside of the school. The interest of practitioners has been supplemented by a considerable amount of research on the learning of mathematics and the use of mathematical knowledge to solve problems. This research has been conducted by cognitive scientists, who seek to develop and validate theories of human learning and problem solving, and mathematics educators, who seek to understand the nature of the cognitive interaction between students and the mathematical subject matter they study and the problems they solve. This chapter briefly summarizes some of the most salient features of the cognitive theory and research and draws from that research a few suggestions for designing mathematics instruction that will produce students that are better equipped to use their mathematical knowledge to solve problems. [Topics: 5a, 9, 16] 1987-065

Silver, E. A. (1987). Perusing the problem-solving panorama: Comments on six papers on mathematical problem solving. In J. C. Bergeron, N. Herscovics, & C. Kieran (Eds.), *Proceedings of the Eleventh International Conference for the Psychology of Mathematics Education* (Vol. 2, pp. 206-212). Montreal: International Group for the Psychology of Mathematics Education.
This article presents a review of six papers. The remarks concerning these papers are embedded in a broader commentary on the current state of research on mathematical problem solving as compared with the situation Kilpatrick described nearly two decades ago. Beyond specific comments on the six research reports, this review argues that these papers, although quite varied in their theoretical foundations and methodological approaches, share some commonalities, in that they represent instantiations of trends in contemporary research on mathematical problem solving. [Topic: 5a] 1987-066

Silver, E. A. (1987). Research on mathematical problem solving in the United States of America: Some recent trends. In J. P. Becker & T. Miwa (Eds.), *Proceedings of the U.S.-Japan seminar on mathematical problem solving* (pp. 33-62). Carbondale, IL: Southern Illinois University.
This article discusses the current state of research on mathematical problem solving in the United States, focussing particularly on some recent trends. [Topics: 5a, 6] 1987-067

Silver, E. A. (1988). NCTM curriculum and evaluation standards for school mathematics: Responses from the research community. *Journal for Research in Mathematics Education*, 19, 338-344.
This article--prepared for the NCTM Research Advisory Committee--discusses research-related issues raised by the release of the NCTM Curriculum and Evaluation Standards for School Mathematics in 1987. Although the Standards document contains many recommendations, those recommendations which do not rest on a solid research base may be viewed as strategic sites for new research activity. Moreover, it is argued that the field may need to embark on a transformative research agenda that closely aligns with the heads of instructional reform implied by the NCTM Standards. [Topic: 4] 1988-056

Silver, E. A. (1988). Solving story problems involving division with remainders: The importance of semantic processing and referential mapping. In M. J. Behr, C. B. Lacampagne, & M. M. Wheeler (Eds.), *Proceedings of the Tenth Annual Meeting of the North American Chapter of the IGPME* (pp. 127-133). DeKalb, IL: Northern Illinois University.
Students' ability to solve division story problems involving remainders was examined in this article. Embedding a target division problem involving remainders in a small set of related problems enhanced student performance. The enhanced performance is explained in terms of students engaging in relevant semantic processing and mapping between and among three referential systems: the story text, the story situation, and the mathematical model. [Topic: 5a] 1988-057

Silver, E. A. (1988). Teaching and assessing mathematical problem solving: Toward a research agenda. In R. Charles & E. Silver (Eds.), *Research agenda for mathematics education: Teaching and assessing mathematical problem solving* (pp. 273-282). Reston, VA/Hillsdale, NJ: National Council of Teachers of Mathematics/Erlbaum.
This chapter is part of a volume which is the product of one of four NCTM Research Agenda Project conferences held during 1987. This chapter focuses on the teaching and evaluation of problem solving. Research related to problem solving over the past ten years has focused almost exclusively on analyses and characterizations of problem-solving competence and performance. Very little research has been conducted on issues more closely concerned with teaching and assessing problem solving. A major purpose of this work is to open new lines of attack on fundamental issues related to the teaching and evaluation of problem solving. [Topics: 3, 6] 1988-058

Silver, E. A. (1989). On making sense of number sense. In J. Sowder & B. Schappelle (Eds.), *Establishing foundations for research on number sense and related topics: Report of a conference* (pp. 92-96). San Diego, CA: Center for Research in Math & Science Education.

This chapter proposes several issues related to the context of mathematical problem solving that might also be relevant for consideration in the area of number sense. After reviewing recent research in the area of students' sense-making abilities on story problems involving division with remainders, the findings are related to the general topic of number sense. A research agenda is proposed to increase understanding of some specific components of number sense. [Topic: 10] 1989-066

Silver, E. A. (1990). Contributions of research on mathematics teaching and learning to educational practice: Applying findings, methods, and perspectives. In T. J. Cooney (Ed.), *Mathematics teaching and learning in the 1990s (NCTM 1990 Yearbook)* (pp. 1-11). Reston, VA: National Council of Teachers of Mathematics.

This chapter explores the relationship between educational practice and educational research on the teaching and learning of school mathematics. It is argued that several different aspects of research on the teaching and learning of mathematics--including the methods, theoretical constructs, theoretical perspectives, as well as the findings--have potential for making substantial contributions to educational practice. Each of these areas is addressed independently and examples are provided. [Topics: 1, 5a] 1990-072

Silver, E. A., & Adams, V. M. (1988). Comparing problems. In P. G. O'Daffer (Ed.), *Problem solving: Tips for teachers* (pp. 58-59). Reston, VA: National Council of Teachers of Mathematics.

This article provides tips for teachers in the area of teaching problem solving in mathematics. It discusses the comparison of problems. [Topics: 5a, 16] 1988-059

Silver, E. A., & Adams, V. M. (1988). Using open-ended problems. In P. G. O'Daffer (Ed.), *Problem solving: Tips for teachers* (pp. 60-61). Reston, VA: National Council of Teachers of Mathematics.

This article provides tips for teachers in the area of teaching problem solving in mathematics. It discusses the use of open-ended problems. [Topics: 5a, 16] 1988-060

Silver, E. A., & Carpenter, T. P. (1989). Mathematical methods. In M. M. Lindquist (Ed.), *Results of the fourth mathematics assessment of the National Assessment of Educational Progress* (pp. 10-18). Reston, VA: National Council of Teachers of Mathematics.

This chapter reports on student performance on logical reasoning, problem solving, proof, and proof-related items on the fourth mathematics assessment conducted by the NAEP. The findings indicate that students at all three (3rd, 7th and 11th) grade levels tend to reason better on items that involve familiar everyday settings rather than on items with abstract contexts. Most 11th-grade students, even those who have studied mathematics each year in high school, demonstrate little understanding of the nature of and mathematical methods involved in proof. [Topics: 3, 5a] 1989-067

Silver, E. A., & Charles, R. (Eds.). (1988). *Research agenda for mathematics education: Teaching and assessing mathematical problem solving*. Hillsdale, NJ/Reston, VA: Erlbaum/National Council of Teachers of Mathematics.

This volume is the product of one of four NCTM Research Agenda Project conferences held during 1987. The conference from which this monograph emerged was initiated because of needs that exist in schools related to the focus of the conference--teaching and evaluation of problem solving--and because of the paucity of research-based knowledge in these areas. [Topics: 3, 6, 16] 1988-061*

Silver, E. A., & Mamona, J. (1989). Problem posing by middle school mathematics teachers. In C. A. Maher, G. A. Goldin, & R. B. Davis (Eds.), *Proceedings of the Eleventh Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 263-269). New Brunswick, NJ: Center for Math, Science & Computer Education, Rutgers.

The problem posing and conjecturing of middle school mathematics teachers was examined in this article. Teachers were asked to produce conjectures in a task environment that allowed exploration of a rich variety of mathematical relationships. Subjects generated conjectures both before and after attempting to solve a specific problem embedded in the same task environment. The findings suggest that the teachers could generate reasonable, interpretable conjectures and problems related to many aspects of the task environment and that there were qualitative differences between the conjectures generated before solving the specific problem and those generated afterwards. [Topics: 5a, 6] 1989-068

Silver, E. A., & Mamona, J. (1989). Stimulating problem posing in mathematics instruction. In G. Blume & M. K. Heid (Eds.), *Implementing new curriculum and evaluation standards* (pp. 1-7). University Park, PA: Pennsylvania Council of Teachers of Mathematics.

This chapter discusses a rationale from both educational and mathematical perspectives for including problem-posing activities in pre-college mathematics classes. Strategies for using

open-ended problems and for modifying other problems to opening closed problems for facilitating problem posing are discussed. The relationship between problem posing and problem solving is also discussed. [Topics: 6, 16] 1989-069

Silver, E. A., & Marshall, S. (1990). Mathematical and scientific problem solving: Findings, issues and instructional implications. In B. F. Jones & L. Idol (Eds.), *Dimensions of thinking and cognitive instruction* (Vol. 1, pp. 265-290). Hillsdale, NJ: Erlbaum.

This chapter is a brief survey of several features of cognitive theory and related research that are directly relevant to mathematical and scientific problem solving. Four general areas are considered: (a) knowledge for problem solving; (b) problem-solving processes; (c) metalevel aspects of problem solving; and (d) instructional characteristics. The chapter concludes with several instructional recommendations drawn for the research review. [Topics: 1, 5a, 5b, 6] 1990-073

Silver, E. A., & Metzger, W. (1989). Aesthetic influences on expert mathematical problem solving. In D. B. McLeod & V. M. Adams (Eds.), *Affect and mathematical problem solving: A new perspective* (pp. 59-74). New York: Springer-Verlag.

Building on an already existing body of literature relating to expert problem solving behavior, data in the form of interview protocols and summaries of protocols of expert problem solvers were examined, and the role of aesthetic judgments on expert mathematical problem solvers was investigated in this chapter. The authors argue that the results indicate that problem-solving expertise is a function of taste as well as competence. Aesthetic factors appear to play two roles in the behaviors of expert problem solvers: (a) aesthetic principles serve as a basis for post hoc evaluation of solutions or problems, and (b) aesthetic principles guide decision making during problem solving. The relevance of these findings for instruction is discussed briefly. [Topic: 13] 1989-070

Silver, E. A., & Smith, M. S. (1989). Canceling cancellation: The role of worked-out examples in unlearning a procedural error. In C. A. Maher, G. A. Goldin, & R. B. Davis (Eds.), *Proceedings of the Eleventh Annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 80-86). New Brunswick, NJ: Center for Math, Science & Computer Education, Rutgers.

The study reported in this article examined the effectiveness of using worked examples to remediate a procedural error in the domain of algebra. Extrapolating from research on learning from worked examples, it was hypothesized that exposure to instructional treatments involving the use of correctly worked examples or incorrectly worked examples, in which the cancellation error was made salient, would help students eliminate that procedural error from their repertoire. Both treatments were successful in helping students significantly reduce the number of cancellation errors made when simplifying rational expressions. Evidence suggests that worked-out examples may be useful in helping students detect and correct procedural errors. [Topics: 5a, 6] 1989-071

Silver, E. A., & Smith, M. S. (1990). Research into practice: Teaching mathematics and thinking. *Arithmetic Teacher, 37*(8), 34-37.

This article discusses some recent research on teaching high-level thinking skills in order to provide a rationale for giving greater emphasis to reasoning and thinking in elementary school mathematics instruction. Suggestions for classroom practice include the use of problems with multiple methods of solution, open-ended problems and situational problems. [Topics: 5a, 6, 16] 1990-074

Silver, E. A., Kilpatrick, J., & Schlesinger, B. (1990). *Thinking through mathematics*. New York: The College Board.

This book offers a view of mathematics as emerging largely from individual and social activity rather than only from textbooks, worksheets, and tradition. The learner of mathematics is pictured as someone who actively constructs meaning rather than passively receives it. The authors consider how a greater emphasis on communication in the mathematics classroom yields dividends, they explore how teachers might encourage greater inquiry and communication in a secondary school class by making minor, but thought-provoking, changes in ordinary problems and situations, and the authors offer some practical advice on getting started in the risky, but rewarding, business of transforming the mathematics classroom into a place where students are expected not only to absorb and consume mathematics but also to produce and think about it. [Topics: 5a, 6, 16] 1990-075*

Silver, E. A., Lindquist, M. M., Carpenter, T. P., Brown, C. A., Kouba, V., L. & Swafford, J. O. (1988). The fourth NAEP Mathematics Assessment: Performance trends and results and trends for instructional indicators. *Mathematics Teacher, 81*, 720-727.

This article is the third of three articles to appear in the Mathematics Teacher reporting the

seventh-grade and eleventh-grade results of the fourth mathematics assessment of the National Assessment of Educational Progress (NAEP). This article discusses trends in performance across the last three NAEP mathematics assessments. The results indicate that overall levels of proficiency for all age, ethnic and gender groups are far too low. Although students appear to have mastery of basic computational skills, there exist serious gaps in their knowledge of underlying concepts and their ability to apply their knowledge to solve problems. [Topics: 3, 5a] 1988-062

St. James, J. D., & Schneider, W. (1991). Student MEL software support for instructors and teaching assistants in research methods course. *Behavior Research Methods, Instruments, & Computers, 23*(2), 149-154.

A number of common problems plague the teaching of an undergraduate research methods course including: training of teaching assistants, providing meaningful experimental materials, and handling data acquisition and analysis. This article discusses the Student Micro Experimental Laboratory (MEL), which offers a systematic approach to the management of a computerized research methods laboratory course by combining high-quality experiments in many areas of psychology with background materials to help the instructor and teaching assistant. The software presents and collects data from 28 experiments. The data can be analyzed for single subjects and for classes as a whole. Students can rapidly implement new experiments in a variety of paradigms. An expanding library of experiments created by students and instructors should provide an expanding environment for teaching experimental research methods. Instructor's materials and the student workbook provide additional support and information. [Topic: 7] 1991-069

Stein, M. K., Baxter, J., & Leinhardt, G. (1989). *Teacher subject matter knowledge and its relationship to classroom instruction* (Tech. Rep. No. CLIP-89-01). Pittsburgh, PA: University of Pittsburgh, LRDC.

This report investigates the level and kind of teacher subject-matter knowledge needed for elementary instruction. An experienced fifth-grade teacher was studied in the context of teaching functions and graphing. The teacher's subject-matter knowledge was compared to that of two math experts. Results of this comparison and an examination of lesson transcripts showed limitations in the teacher's subject matter knowledge and instances of missed opportunities in classroom presentations. [Topics: 5a, 13, 16] 1989-072

Stein, M. K., Baxter, J., & Leinhardt, G. (1990). Subject-matter knowledge and elementary instruction: A case from functions and graphing. *American Educational Research Journal, 27*(4), 639-663.

This article describes the relationship between teachers' subject-matter knowledge and their lesson presentations by reporting on a study of one experienced 5th-grade mathematics teacher teaching 25 lessons on functions and graphing. The teacher's subject matter knowledge (gleaned from lesson videotapes and interviews) was compared to that of a math educator. Specific limitations in the teacher's knowledge were identified and implications of this, both for instruction and for teacher education, are discussed. [Topics: 5a, 13, 16] 1990-076

Stein, M. K., Leinhardt, G., & Bickel, W. (1989). Instructional issues for teaching students at risk. In R. E. Slavin, N. L. Karweit, & N. A. Madden (Eds.), *Effective programs for students at risk* (pp. 145-194). Boston: Allyn and Bacon.

This chapter addresses the issue of how best to educate all types of low-achieving students. It reviews past efforts to serve separately compensatory education students, mildly handicapped students (including LD), and other slow learners. The authors argue that these students all benefit from the same kinds of effective instructional programs. Recent improvements in instructional practice and new findings in educational research support their position. [Topics: 4, 16, 17] 1989-073

Swafford, J. O., Silver, E. A., & Brown, C. A. (1989). Findings from the fourth national mathematics assessment in the United States. In D. F. Robitaille (Ed.), *Evaluation and assessment in mathematics education* (pp. 97-104). Paris, France: UNESCO.

Findings from the Fourth NAEP assessment of mathematics are examined, and trends across the national sample, among minorities and by gender are reported in this chapter. Special attention is given to data related to students' problem-solving and reasoning abilities. The data indicate a slight upturn in achievement in mathematics in the United States in the 1980's, yet the progress appears to have occurred solely in the domain of lower-order skills. Recommendations are made for a reorientation of the school mathematics curriculum to place greater emphasis on helping students to become more effective mathematical problem solvers and to improve their ability to

communicate and reason mathematically. [Topics: 3, 5a] 1989-074

Swartout, W. R., Paris, C. L., & Moore, J. D. (1991). Design for explainable expert systems. *IEEE Expert, 6*(3), 58-64.

This article describes two types of design knowledge that are critical for producing effective explanations of the knowledge and decision-making of expert systems. [Topics: 2, 12] 1991-070

Thornton, H. S., & Zigmond, N. (1988). Secondary vocational training for LD students and its relationship to school completion status and post school outcomes. *Illinois School Journal, 67*(2), 37-54.

The purpose of this article is provide a chronology of the authors' research to date and a brief summary of some of their most significant findings. The authors focus particularly on the post school outcomes for learning disabled students who accessed mainstream vocational education programs in high school. The article concludes with a discussion of issues derived their findings that secondary school personnel may want to consider in the delivery of vocational education services to learning disabled adolescents. [Topic: 17] 1988-063

Thornton, H., & Zigmond, N. (1989). Transition to the world of work for LD young adults. *Journal of Learning Disabilities.*

This article reports the level of adjustment to the world of work for a sample of post secondary age urban LD graduates and dropouts and a control sample of non-LD peers. Reported adjustment factors include current employment rates, number of jobs held since high school, current wages, percentage of time employed since high school, types of employment, ways of finding jobs, reasons for leaving jobs, current training rates, types of current training, and for the LD sample, transitional service access and outcome. [Topic: 17] 1989-075

Utley, B., Zigmond, N., & Strain, P. (1987). How various forms of data affect teacher analysis of student performance. *Exceptional Children, 53*(5), 411-422.

Special education teachers are routinely taught to collect and analyze student performance data. Data collection and analysis are assumed to be necessary for accurate analysis of three possible trends: (1) an upward trend; (b) a level trend; and (c) a downward trend. Few studies have examined the accuracy of trend analysis when teachers simply observe consecutive training sessions, nor has there been sufficient comparison of the accuracy of trend analysis based on various forms of data. The study reported in this article examined the effects of observation and various forms of data on teachers' ability to accurately analyze trends. [Topic: 17] 1987-068

Valdiserri, R. O., Lyter, D. W., Kingsley, L. A., Leviton, L. C., Schofield, J. W., Huggins, J., Ho, M., & Rinaldo, C. R. (1987). The effect of group education on improving attitudes about AIDS risk reduction. *New York State Journal of Medicine, 87*, 272-278.

Four hundred sixty-four homosexual and bi-sexual men participated in a peer-led, small-group educational session promoting AIDS risk reduction. Although levels of knowledge about AIDS and human immunodeficiency virus (HIV) transmission were uniformly high prior to intervention, at least 60% of the men reported having engaged in unprotected, receptive anal intercourse with more than one partner in the preceding six months. Prior to intervention, a substantial number of men had mixed feelings about AIDS risk reduction or endorsed negative attitudes about AIDS risk reduction. After attending the session, attitudes improved significantly in five of the six areas surveyed. This chapter discusses how this type of intervention may be effective in enabling homosexual and bisexual men to adopt low-risk sexual activities by influencing the nonhealth motives of sexual behavior, especially peer norms about safe sex. [Topic: 8] 1987-074

Vallecorsa, A. L., Zigmond, N., & Henderson, L. M. (1985). Spelling instruction in special education classrooms: A survey of practices. *Exceptional Children, 52*(1), 19-24.

Special education teachers were asked to differentiate between practices for spelling instruction which do and do not have adequate empirical support. The teachers were also asked to report on the extent to which they employed various instructional practices in teaching spelling. Outcomes suggest that special educators may have several misconceptions concerning appropriate and inappropriate methods of instruction. Further, it appears that teachers use a variety of methods on a regular basis which lack empirical support in teaching spelling. Several suggestions for improving training and practice are presented. [Topic: 17] 1985-046

VanLehn, K. (Ed.). (1991). *Architectures for intelligence.* Hillsdale, NJ: Erlbaum.

The book discusses computing systems that exhibit intelligent behavior. Authors of some chapters address only man-made computing systems (i.e. computers), other authors address only biological computing systems (i.e. minds),

and the remaining authors intend their observations to apply to both computers and minds. [Topics: 2, 7, 9] 1991-071*

VanLehn, K., & Ball, W. (1991). Goal reconstruction: How Teton blends situated action and planned action. In K. VanLehn (Ed.), *Architectures for intelligence* (pp. 147-188). Hillsdale, NJ: Erlbaum.
People can reconstruct goal structures and other aspects of their internal state that have been forgotten. This capability is called goal reconstruction. Because goal reconstruction requires no special training and does not have to be acquired separately for each new problem solving procedure one learns, goal reconstruction is arguably a fundamental, task-general capability of human problem solvers. Goal reconstruction is also a useful capability for an artificial problem solver. It permits recovery from interruption of the problem solving by processes that modify the body of procedural knowledge, such as an inferential learning process or a programmer debugging the procedural knowledge. In short, goal reconstruction is both a fundamental human capability and a useful capability for AI architectures. This paper discusses computational mechanisms for implementing an in principle tradeoff between perceptual and cognitive maintenance of goals. [Topics: 6, 9, 13] 1991-072

VanLehn, K., & Jones, R. M. (1991). Learning physics via explanation-based learning of correctness and analogical search control. In L. Birnbaum & G. Collins (Eds.), *Machine learning: Proceedings of the Eighth International Workshop* (pp. 110-114). San Mateo, CA: Morgan Kaufmann.
This chapter discusses Cascade, which models humans learning college physics by studying examples and solving problems. It simulates the main qualitative phenomena visible in human protocols of learning, including several strategies for analogical and non-analogical problem solving, and two strategies for studying examples. It learns at the knowledge level by acquiring new physics rules, and it learns search control knowledge. Most importantly, it models a recently observed phenomenon, the self-explanation effect, which correlates students' example studying strategies with the amount they learn. [Topic: 5b] 1991-073

VanLehn, K., Jones, R. M., & Chi, M. T. H. (1991). Modeling the self-explanation effect with Cascade 3. *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society* (pp. 137-142). Hillsdale, NJ: Erlbaum.
Several investigations have found that students learn more when they explain examples to themselves while studying them, refer less often to the examples while solving problems, and read less of the example each time they refer to it. These findings, collectively called the self-explanation effect, have been reproduced by the authors' cognitive simulation program, Cascade. Cascade has two kinds of learning. It learns new rules of physics by resolving impasses with reasoning based on overly general, non-domain knowledge. It acquires procedural competence by storing its derivations of problem solutions and using them as analogs to guide its search for solutions to novel problems. Several runs of Cascade are discussed in this article where strategies for explaining examples is varied and initial domain knowledge is held constant. These computational experiments demonstrate the computational sufficiency of a strategy-based account for the self-explanation effect. [Topic: 5b] 1991-074

Vesonder, G. T., & Voss, J. F. (1985). On the ability to predict one's own responses while learning. *Journal of Memory and Language, 24*, 363-376.
Two experiments are reported in this article. The first concerns the issue of how accurately, in a multiple-trial learning situation, individuals are able to predict their own performance on a trial-by-trial basis over the entire course of acquisition.The data support previous findings, indicating that subjects are able to discriminate items they have learned in the course of acquisition from those they have not learned. The second experiment examines what information a person uses to predict his or her own acquisition performance and to what extent that information is unique to the particular individual doing the predicting. [Topic: 9] 1985-047

Voss, J. F. (1986). Social studies. In R. F. Dillon & R. J. Sternberg (Eds.), *Cognition and instruction* (pp. 205-239). New York: Academic Press.
This chapter presents a model of instruction in social studies. The model is based upon the information processing model of problem solving, especially as the model refers to the solving of ill-structured problems. [Topic: 5d] 1986-044

Voss, J. F. (1987). Basic and applied research as problem solving: An analysis of constraints. *International Journal of Psychology, 22*, 463-469.
This article considers the question of whether pure or basic research and applied research may be meaningfully differentiated. Basic and applied research are considered in terms of problem-solving, and the question addressed is how basic and applied research vary with respect to the constraints that are placed upon the investigator in relation to the problem-solving process. Three examples are presented, one of

basic research, one of applied, and one between the constraints being examined in each case. The analysis of the three cases leads to the conclusion that basic and applied research are qualitatively different. [Topic: 1] 1987-069

Voss, J. F. (1987). Learning and transfer in subject-matter learning: A problem-solving model. *International Journal of Educational Research. Special issue: Acquisition and transfer of knowledge and cognitive skills, 11*, 607-622.
The growth of the cognitive movement, with its emphasis upon perception and memory, has been accompanied by a decrease in the study of learning, retention, and transfer as found in the traditional associationistic framework. A reconceptualization of learning and retention is presented in this article, making these concepts subordinate to the concept of transfer, and emphasizing prior knowledge, skills, attitudes, and other characteristics of the individual. It is argued that the general information-processing model of problem solving, especially as applied to ill-structured problems, provides a conceptual framework for the study of learning, and is especially useful when considering learning in academic subject-matter domains. [Topics: 5c, 9, 14] 1987-070

Voss, J. F. (1988). Problem solving and reasoning in ill-structured domains. In C. Antaki (Ed.), *Analyzing everyday explanation: A casebook of methods* (pp. 74-93). London, England: SAGE.
This chapter, methodological in orientation, presents a description of analyses of ill-structured problems. Emphasis is placed upon how such analyses can help to understand thought processes, and limitations of the method are considered. [Topic: 6] 1988-064

Voss, J. F. (1989). On the composition of experts and novices. In E. Maimon, B. Nodine, & F. O'Connor (Eds.), *Thinking, reasoning, and writing*. White Plains, NY: Longman Press.
This chapter presents the position that the development of a better understanding of the processes underlying the solving of ill-defined problems, including the processes of informal reasoning, will lead to a better understanding of the complex acts of everyday behavior, including tasks such as writing. Brief summaries of research on the solving of ill-structured problems by experts and novices and of some research on informal reasoning are presented, indicating how such research on problem solving and reasoning may enhance our understanding of instruction in other complex tasks. [Topics: 6, 13] 1989-076

Voss, J. F. (1989). Problem solving and the educational process. In A. Lesgold & R. Glaser (Eds.), *Foundations for a psychology of education* (pp. 251-294). Hillsdale, NJ: Erlbaum.
This chapter presents a summary of problem solving and its relation to the educational process. A broad-based but not exhaustive literature survey emphasizes the importance of problem solving in instruction. [Topic: 6] 1989-077

Voss, J. F. (1990). Reasoning by argumentation. In H. Mandl, E. De Corte, N. Bennett, & H.F. Friedrich (Eds.), *Learning and instruction: European research in an international context* (Vol. 2.1, pp. 305-319). Oxford: Pergamon Press.
This chapter stresses the importance of the teaching of argumentation in reference to instruction in reasoning. Emphasis is placed on justification processes. [Topic: 6] 1990-077

Voss, J. F. (1991). Informal reasoning and international relations. In J. F. Voss, D. N. Perkins, & J. Segal (Eds.), *Informal reasoning and education* (pp. 37-58). Hillsdale, NJ: Erlbaum.
The two primary objectives of this chapter are to explore the nature of informal reasoning in international relations, a special case of reasoning in the social sciences, and to consider how instruction could help enhance the quality of informal reasoning found in the social sciences. The first section discusses the international relations context, serving as a setting for the second section, in which reasoning in international relations is considered, including the findings of several related studies. The third section addresses the question of how instruction may facilitate one's reasoning in the social science domain. [Topics: 6, 16] 1991-075

Voss, J. F., & Bisanz, G. L. (1985). Knowledge and the processing of narrative and expository text: Some methodological issues. In B. K. Britton & J. B. Black (Eds.), *Understanding expository text: A theoretical and practical handbook for analyzing explanatory text* (pp. 385-391). Hillsdale, NJ: Erlbaum.
In this chapter, the authors discuss some problems that occur when one attempts to study the role of knowledge and text processing. These problems include: difficulty in assessing knowledge; problems associated with the use of the contrastive method; issues related to scoring recall protocols; and the need to determine the interaction between text structure and the effects of knowledge. [Topic: 15] 1985-048

Voss, J. F., & Bisanz, G. L. (1985). Knowledge and the processing of narrative and expository texts. In B. K. Britton & J. B. Black (Eds.), *Understanding expository text: A theoretical and practical handbook for analyzing explanatory text* (pp. 173-198). Hillsdale, NJ: Erlbaum.

This chapter assesses the current state of research on how knowledge influences text processing. Interestingly, research on narrative text has tended to focus upon the role of knowledge while research on expository text has tended to focus on the role of text structure. Because of this differentiation, this chapter begins with a discussion on knowledge and the processing of narrative text. The second part focuses upon the role of knowledge in processing expository text, drawing comparisons to narrative when appropriate. Finally, there is a brief concluding section. [Topic: 15] 1985-049

Voss, J. F., & Means, M. L. (1989). Toward a model of creativity based upon problem solving in the social sciences. In J. A. Glover, R. R. Ronning, & C. R. Reynolds (Eds.), *Handbook of creativity: Assessment, theory and research* (pp. 399-410). New York: Plenum Press.

This chapter presents a model of creativity that is based upon the solving of ill-structured social science problems, emphasizing the importance of the individual's knowledge base, the effective use of a variety of search mechanisms that provide for obtaining and evaluating information, and the operation of value and affect components. The fact that cited examples of creativity are seldom found in social sciences is largely attributed to social science research not meeting the criteria that are typically interpreted. Finally, some suggestions are proposed with respect to social science instruction that would hopefully lead to an increase of creativity in students. [Topics: 2, 6] 1989-078

Voss, J. F., & Post, T. A. (1988). On the solving of ill-structured problems. In M. T. H. Chi, R. Glaser, & M. J. Farr (Eds.), *The nature of expertise* (pp. 261-285). Hillsdale, NJ: Erlbaum.

Reitman (1965) and Simon (1973) have provided excellent analyses of the nature of ill-structured problems and how they are solved. The research reported in this chapter extends the analyses of Reitman and Simon by pointing to a number of the complexities of solving ill-structured problems. General issues are discussed that require consideration if a better understanding of the solving of such problems is to be established. [Topic: 6] 1988-065

Voss, J. F., Blais, J., Means, M. L., Greene, T. R., & Ahwesh, E. (1989). Informal reasoning and subject matter knowledge in the solving of economics problems by naive and novice individuals. In L. B. Resnick (Ed.), *Knowing, learning and instruction: Essays in honor of Robert Glaser* (pp. 217-250). Hillsdale, NJ: Erlbaum.

This chapter reports on a study which investigated how subject matter knowledge and the use of informal reasoning mechanisms are related to the solving of economics problems by naive and novice individuals. Participants answered questions about changes in automobile prices, the federal deficit, and interest rates. The results suggest that classroom instruction in economics does not necessarily lead to superior performance on everyday economics tasks and that individuals with a strong intellectual history may not acquire economics knowledge from everyday experience. Application of an informal reasoning model indicates that college educated individuals differ from those with no college education on several reasoning measures. [Topics: 6, 13] 1989-079

Voss, J. F., Fincher-Kiefer, R. H., Greene, T. R., & Post, T. A. (1986). Individual differences in performance: The contrastive approach to knowledge. In R. J. Sternberg (Ed.), *Advances in the psychology of human intelligence* (Vol. 3, pp. 297-334). Hillsdale, NJ: Erlbaum.

This chapter presents a review of research involving the contrastive method, the extent to which a characteristic in question is related to performance on some other task. Of specific interest is use of this method when the characteristic in question is some type of knowledge assessment and the comparison task is performance on some type of information processing task. A methodologically centered summary of research is presented, providing a type of case study in the use of contrastive methodology. Finally, a critical evaluation of contrastive methodology is presented. [Topic: 13] 1986-045

Voss, J. F., Perkins, D. N., & Segal, J. W. (Eds.). (1991). *Informal reasoning and education*. Hillsdale, NJ: Erlbaum.

This edited book contains chapters that show how informal reasoning may be found in various subject matter domains and what constitutes the conceptual basis of informal reasoning. In addition, informal reasoning is considered in relation to instructional practice. [Topic: 6] 1991-076*

Voss, J. F., Vesonder, G. T., Post, T. A., & Ney, L. G. (1987). Was the item recalled and if so by whom? *Journal of Memory and Language, 26*, 466-479.

This article is concerned with the extent to which individuals can remember their own responses in a learning situation. The results generally indicate that a person can remember what was recalled in a dyad situation, but not whether he, she, or the other person recalled it. [Topic: 9] 1987-071

Voss, J. F., Wolfe, C. R., Lawrence, J. A., & Engle, R. A. (1991). From representation to decision: An analysis of problem solving in international relations. In R. J. Sternberg & P. Frensch (Eds.), *Complex problem solving: Principles and mechanisms* (pp. 119-158). Hillsdale, NJ: Erlbaum.

This chapter addresses the question of how problem representation is related to generation of alternatives in decision making. Four problem areas are studied. Two were taken from political science literature, the Cuban Missile Crisis and the American intervention in Korea, and two involved collecting problem solving protocols, one on German reunification and one on the anti-nuclear movement. [Topic: 6] 1991-077

Voss, J. F. (1990). On the solving of ill-structured problems: A review. *Unterrichts Wissenschaft, 18*, 313-317.

This article is concerned with the question of how people solve ill-structured problems. While not extensive, research on this question has produced a substantial database and theoretical framework. This article summarizes the progress and describes the issues that need to be addressed in order to better understand how such problem solving takes place. The first section, Definition of the Problem, presents a discussion of ill-structured problems. Section two, Developing the Database, presents a non-exhaustive research summary. The third section, Issues of Concern, describes the theoretical and methodological problems. The final section presents a brief summary. This article was published in a German journal, but is available from the author in English. [Topic: 6] 1990-078

Wallace, R. C. Jr., LeMahieu, P. G., & Bickel, W. E. (1990). The Pittsburgh experience: Achieving commitment to comprehensive staff development. In B. Joyce (Ed.), *Changing school culture through staff development: 1990 ASCD yearbook* (pp. 185-202). Alexandria, VA: Association for the Supervision of Curriculum Development.

This chapter reports on the use of staff development as a major tool for educational reform in an urban school district. [Topic: 4] 1990-079

Wattenmaker, W. D. (1991). Learning modes, feature correlations, and memory-based categorization. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17*(5), 908-922.

Several pairs of correlated features were embedded in descriptions that had a wealth of exemplar-specific (i.e., idiosyncratic) information, and sensitivity to these correlations was examined as a function of intentional and incidental encoding conditions. Participants in incidental conditions were able to access information about several embedded correlations, even when complex inferences were required to recover correlations. In intentional conditions, however, little access to correlations was observed. The results are discussed in this article in terms of the advantages of storing examples for addressing unanticipated needs and goals. [Topics: 6, 9, 10] 1991-078

Wattenmaker, W. D., & Shoben, E. J. (1987). Context and the recallability of concrete and abstract sentences. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13*(1), 140-150.

This article reports on three experiments that were performed to examine the influence of contextual information on the recall of abstract and concrete sentences. Concrete and abstract target sentences were presented in either a coherent paragraph context or a random paragraph context. In the random context, subjects recalled more concrete target sentences than the abstract ones, but there was no difference between the two groups when the sentences were presented in a coherent context. The results were interpreted in terms of the differential availability of contextual information for abstract and concrete materials, and were taken as supporting the context availability model. [Topics: 9, 10, 15] 1987-072

Wattenmaker, W. D., Nakamura, G. V., & Medin, D. L. (1988). Relationships between similarity-based and explanation-based categorization. In D. Hilton (Ed.), *Contemporary science and natural explanation: Common sense conceptions of causality* (pp. 204-240). Brighton, England: Harvester Press.

Relationships between similarity-based and explanation-based categorization are discussed in this chapter. The authors propose that a complete account of conceptual coherence will require an understanding of a similarity-based component and a knowledge-based component. [Topics: 2, 6, 10] 1988-066

Whitley, B. E., Jr., & Schofield, J. W. (1986). A meta-analysis of research on adolescent contraceptive use. *Population and Environment, 8*(3 & 4), 173-203.

Meta-analysis was used to summarize the results of 134 studies of adolescent contraceptive use in relation to two major explanatory models: the career model and the decision model. There was evidence in support of both models, although less research has been conducted on the decision model. The major variables affecting young women's contraceptive use were partner influence to use contraception, acceptance of one's sexuality, future orientation, positive attitudes toward contraception, an exclusive sexual relationship,

and frequency of intercourse. The major variables affecting young men's contraceptive use were partner influence, frequency of intercourse, and positive attitudes toward contraception. Possible future directions for research are noted. [Topic: 4] 1986-046

Wilson, T. D., & Schooler, J. W. (1991). Thinking too much: Introspection can reduce the quality of preferences and decisions. *Journal of Personality and Social Psychology, 60*(2), 181-192.
The research described in this article examined the effects of verbally analyzing reasons for preferences and decisions. It is found that analyzing reasons can focus people's attention on nonoptimal criteria, causing them to base their subsequent choices on these criteria. [Topic: 9] 1991-079

Zigmond, N. (1990). Rethinking secondary school programs for students with learning disabilities. *Focus on Exceptional Children, 23*(1).
Since 1975, there has been an enormous increase of concern for, programming with, research on, and literature about students with learning disabilities in high school, and in the transition from school to work or further education. After reviewing past service delivery models and efficacy data, two models of services are proposed in this article. These models incorporate four components that are believed to have potential for meeting the goals of a meaningful high school education and a smooth transition to life beyond school. Important implications for staffing and teacher preparation as well as for general school policy and administration are also addressed. [Topic: 17] 1990-080

Zigmond, N. (1991). *Learning disabilities from an educational perspective.* National Institute of Health. [Topic: 17] 1991-080

Zigmond, N., & Baker, J. (1991). Mainstreaming experiences for learning disabled students: A preliminary report. *Exceptional Children, 57*(2), 176-185.
In response to calls for alternative elementary level service delivery models for students with learning disabilities, the authors developed MELD (Mainstream Experiences for the Learning Disabled). The model seeks not only to accommodate learning disabled students in the mainstream, but also to alter the conditions which led to the referral of students to special education in the first place. [Topic: 17] 1991-081

Zigmond, N., & Miller, S. (1986). Assessment for instructional planning. *Exceptional Children, 52*(6), 501-509.
The purpose of this article is to present some current thinking on assessment for instructional planning. Prevailing practices for determining what to teach and how to teach will be reviewed and evaluated. This article provides a framework within which to view this assessment process and a modest re-conceptualization of what to teach and how to teach assessment paradigm. [Topic: 17] 1986-047

Zigmond, N., & Miller, S. E. (1991). Improving high school programs for students with learning disabilities: A matter of substance as well as form. In F. Rush & L. DeStefano (Eds.), *Special education students in transition.* Champaign, IL: Sycamore Press.
It has been 15 years since the passage of PL94-142 and the assurance by the federal government of a free and appropriate public education to students with handicaps. In that time, the numbers of students served in special education programs has grown to nearly 4.5 million, an increase of 21% over 1976-77 counts. [Topic: 17] 1991-082

Zigmond, N., & Sansone, J. (1986). Designing a program for the learning disabled adolescent. *RASE, 7*(5), 13-17.
In the past decade, there has been a significant increase in the numbers of students at the secondary school level who are labeled learning disabled and placed in special education programs. These LD students are a heterogeneous group in need of a diverse set of curricular offerings. This article reviews program options that have been implemented by school districts and provides a useful model for conceptualizing services to LD adolescents. Factors that influence program selections are also reviewed. [Topic: 17] 1986-048

Zigmond, N., & Thornton, H. (1986). Follow-up of post-secondary age learning disabled graduates and drop-outs. *LD Research, 1*(1), 50-55.
This article reports the drop-out rates, basic skill competency level, and employment status of a group of learning-disabled postsecondary age youth and a control group of 61 non LD same age peers. Findings indicated significantly higher drop out rates and significantly lower basic skills competency levels among LD youth. Both LD and NLD high school drop outs were employed at time of follow-up at a significantly lower rate than their graduating peers. Educational implications of these findings are discussed. [Topic: 17] 1986-049

Zigmond, N., & Thornton, H. (1988). Learning disabilities in adolescents and adults. In K. Kavale (Ed.), *Learning disabilities: State of the art and practice.* San Diego, CA: College Hill Press. [Topic: 17] 1988-067

Zigmond, N., Kerr, M. M., & Schaeffer, A. (1988). Behavior patterns of learning disabled and non-learning disabled adolescents in high school academic classes. *RASE*, 9(2), 6-11.

The study reported in this article sought to describe the classroom behavior patterns of learning disabled adolescents in mainstream academic classes. The school survival skills of the 36 LD students in regular high school classes were measured through direct observation. These observational data were compared with data on emotionally disturbed students and a control sample of nonhandicapped students in the same mainstream classes. [Topic: 17] 1988-068

Zigmond, N., Levin, E. & Laurie, T. E. (1985). Managing the mainstream: An analysis for teacher attitudes and student performance in mainstream high school programs. *Journal of Learning Disabilities, 18*(9), 535-541.

Four studies were undertaken in 12 urban high schools to explore the accommodative power of mainstream secondary schools and the extent to which teacher attitudes and student behaviors contributed to failure of learning disabled students in regular high school classes. Findings suggest that mainstream teachers recognize the low achievement of LD students but do very little that is different instructionally when these students are assigned to regular content classes. The one adjustment that is commonly made is to lower grading standards so that LD students have a good chance of passing the course. In fact, most LD students received passing grades in most of their mainstream courses and most failing grades were in courses in which attendance records were extremely poor. [Topic: 17] 1985-050

Zigmond, N., Sansone, J., Miller, S. E., Donahoe, K. A. & Kohnke, R. (1985). Teaching learning disabled students at the secondary school level, what research and experience say to the teacher of exceptional children. *Learning Disabilities Focus, 1*(2), 108-115.

This article explains how to design a program for the learning disabled adolescent, how to plan for instruction, how to organize instruction to maximize student learning, and how to go beyond direct services for the LD adolescent. It also offers recommendations for the LD teacher. [Topic: 17] 1985-051

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